ENVIRONMENTAL IMPROVEMENT OF SLUMS IN BOMBAY: COMMUNITY – BASED SOLID WASTE MANAGEMENT FOR GILBERT HILL – GAMDEVI DONGRI

Submitted to International Development Research Centre, Canada

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INTRODUCTION

Solid wastes have been a result of man's activities from earliest civilization. This became more prominent during the industrial revolution and with technological developments has become more and more intensified and complex.

In the first 40 years if this century, India was an agrarian society, its urban population being less than 12 percent. India's urban population growth between 1981 and 1991 was 36.19%, the rate being much higher in urban areas than in rural areas. By 2020, more than 50 percent of India's population is expected to live in urban areas, with a rapid concentration process of population in larger towns, cities and metropolitan areas. Without the appropriate changes in urban development and attention to urban development problems, the whole country is likely to be affected by a decline in public health, sanitation and environmental conditions. Like many other developing countries, India is still faced with high morbidity and mortality rates. The latest reports for India indicate that the under-five mortality rate in 1997 was 108, and the infant mortality rate was 71. Percent of children who were severely and moderately underweight was 53, with 21% being severely underweight and 52 percent under-fives exhibiting moderate and severe stunting (UNICEF, State of the World's Children, 1998). Further 30 percent of the urban population in India still do not have access to adequate sanitation.

Morbidity is intimately inter-linked with under-nutrition and has tremendous, vast-reaching implications for the socio-economic development of communities and the nation. The state of the environment, sanitation and hygiene, in turn, determine the risks for morbidity. In 1996, 40% of the residents of Mumbai city were estimated to be living in slums, with the population expected to increase with time. With increasing urbanization and the accompanying high population density, the land has been intensively used for not only residential but also commercial and industrial activities, which has led to an adverse impact on the environment. Environmental impact due to gaseous and liquid discharges has received greater attention than has solid waste. Solid waste pollution/land pollution has received limited attention in the past in the country, although it is of significance (1,2).

India has a large number of urban local bodies/municipalities. which are having increasingly greater problems in meeting the infrastructure needs of rapidly increasing populations. In the past, urban development did not receive priority on the development agenda.

The plague crisis in India in late 1994 highlighted the poor state of sanitary conditions in Indian cities and the public health situation in general. However, the clean-up drives which were initiated during the crisis did not sustain their momentum and open dumping of solid waste continued to be practiced as before. While cities remain in squalor, quality of urban life will continue to decline and a permanent sanitation and environmental crisis hampers economic development efforts (1, 2).

The term "waste" implies that it is of no concern to anyone and is not valuable. The intrinsic value of solid waste as a resource or as an object of further utility remained unrecognized to a considerable extent in the past. The net result in this country as well as in this city of Mumbai has been to arrange for its disposal but with meager allocation of resources. The collection, transport, processing and disposal of solid wastes, is a highly visible and important municipal service, involves a large amount of expenditure but has not received much attention from citizens (3).

Sewerage is also widely absent in India (4). Three-fourths of the urban population does not have environmentally adequate excreta disposal and 60 % of the urban population defecates in the open. Solid waste generated by households as well as industry, construction, hospitals etc. pose health risks for urban residents. Added to this is the low coverage of solid waste collection and open and hazardous dumping near industrial areas. Further, there has been tremendous public apathy and entrenched habits and traditions have in turn compounded the problem. Citizens deposit the wastes by the roadside, from where the conservancy staff transfers it to community bins using a wheelbarrow or other equipment. Such primary collection is common in India, which needs a large number of workers and small number of equipment.

The material collected in community receptacles is then transferred to vehicles, which transport the material to the processing, or disposal site. In a typical residential area in the city, the Mumbai Municipal Corporation does not provide for collection of garbage from households. Individual owners of apartment blocks etc. generally hire people to render cleaning services. The garbage, which is collected, is then dumped at the nearest communal bin, which often overflows and is surrounded by garbage.

In many areas, if the communal garbage bin/facility is not "near enough", a new informal dumping site is created: often almost on street corners and many a times, 2 or 3 sites may be found on a single street.

What adds to the problem is that these dumping sites are indiscriminately selected/created, often found near schools, public utility places creating more hazards for health. To date the waste has been disposed generally at sites for landfill. However, the decaying bio-waste pollutes the area for long periods even after the land gets filled of low-lying areas also dislocates the natural drainage creating environmental problems.

Mumbai city is the world's sixth largest metropolis covering 4,175 sq. kms. A World Bank supported study on environmental management in the Mumbai Metropolis Region indicated that 50 to 70 % of the 5000 tonnes of garbage generated daily is collected by the Municipal Conservancy staff. Thus, there is a problem of uncollected garbage lying in the open, around the city. Another problem facing the Island city is that existing landfills are getting full and there is dearth of finding fresh sites.

Thus the country as well as Mumbai city present a long tradition of neglect, apathy and ignorance about the urban environment. Waste management and waste utilization/reuse and recycling is a relatively new practice not very widely spread. On the preventive side, there are not many measures to reduce solid waste generation through restrictions on industries and the enforcement of environmentally friendly product (4).

The situation clearly highlights a need at city level to "rejuvenate the sanitation and solid waste systems". Composting plants need to be built, more garbage collection vehicles need to be operationalised, and better systems for collection of solid waste/garbage, need to be devised with the participation of the private sector and local NGOs. Citizens need to be briefed and educated in a more environmentally conscious behaviour and need to learn where garbage is to be deposited and where it is not. Equally, the public may need to realize that it may be indeed desirable to pay for municipal services, to have a better and more healthy living environment, instead of expecting the "free lunch" to be always available (1).

During the Earth Summit of 1992, the issue of urban environment was put high on the national and local agenda with one of the programme areas being "promotion of the integrated provision of environmental infrastructure: water, sanitation, drainage, hazardous and solid waste management".

Further, the need to develop adequate capacities for local management involving municipal and local bodies, community-based organizations in efficient and replicable service delivery and management was emphasized (4).

Development activities for the creation of "habitable" cities necessitate an integrated approach seeking practicable and affordable systems/strategies for environmental intervention and management (4). One among the positive interventions listed is solid waste collection and management, including the recycling of reusable resources, organic composting techniques, greening etc. (5).

India's cities abound with slums, which have been seen for long as eyesores. However, they are health hazards not only for their residents but also for the city as a whole. Slum up-gradation has been the remedy but environmental improvement in urban slums is an issue, which remains to be addressed in the true sense. There is growing recognition that, on the one hand, there is a need to strengthen the capacity of local government institutions to improve their urban management and financial capabilities, and on the other hand, to support and build on the strengths and resourcefulness of the urban poor themselves (6).

In Mumbai city, where more than half of its population lives in the slums, there is a dire need to look for and develop solutions for sustainable environment management. In this context, the Dept. of Post Graduate Studies and Research in Home Science, S.N.D.T. Women's University, undertook an action-research project supported by the International Development Research Centre, Canada, to develop a community based and implemented and possibly replicable system for disposal of solid waste. This project was implemented in the Gilbert Hill-Gamdevi Dongri slum in the K-West ward in suburban Mumbai

The K-West Ward.

K-West is one of the 23 wards in Mumbai City. covering a total area of approximately 23.39 square kilometers and a population of about 5.80.000 as per the 1991 Census. In this ward. the population has increased by 50 % in the last decade, while the infrastructure for Solid Waste Management (SWM) has remained at the same level. Thus services are not in line with public expectations. There are 68 declared slums in the ward: 7 on municipal land. 15 on Government and 46 on private property (7).

For purpose of Solid Waste Management (SWM), the ward is divided into 2 administrative zones: North and South. These zones are further divided into 13 SWM districts. Each district has a Junior Overseer and there are 8 junior overseer offices (Muster chowkies) located in the K-West ward. The municipal sweepers, drain cleaners and foremen (mukadams) meet in these chowkies and the Junior Overseers assign daily duties to them. The supervisory cadre at the Ward Level is as follows:

WARD OFFICER

↓

Asst. Head Supervisor

↓ Conservancy | ↓ Administrative

Conservancy

↓

Supervisor

- Jr. Overseer (8)*
- Mukadam (36)
- Sweeper (238)
- Drain Cleaner (6)
- Halalkhore (49)
- Motor Loader (74)

(Figures in parentheses represent number of staff)

Source: Scheu, M. and A. Coad (1994): Observations on Solid Waste Management in Bombay 1992 Water Engineering and Development Center (WEDC). Loughborough University of Technology, Leicestershire, 7 –13.

The supervisory cadre consists of 17 junior overseers, two supervisors and one assistant head supervisor. The number of labourers to the inhabitants of K-west ward i.e. the staffing ratio is about 2.1 labourers per 1000 inhabitants.

Street sweeping and drain cleaning activities are carried out seven days per week in a single shift operation. Refuse collection and transport is carried out by 6 vehicles of the Solid Waste Management Department and 25 vehicles and drivers of private contractors. Collection and transport is carried out in two shifts, seven days per week, with reduced crew on Sundays.

The total amount of refuse collected in K-West approximates 170 tons per day. Scheu and Coad (7) observed:

- *General level of efficiency and workmanship is fairly low among mukadams, sweepers and loaders.*
- *Only about 70% of the staff are available for actual work on any day.*
- *It has been alleged that for 7 days after receiving there wages, 30 & of the staff do not report for duty for almost a week because they are drunk.*
- *It has been reported that sweepers and motor loaded did not work more than 3 ½ hours in a shift of 7 hours. The remaining time is used to work on private premises for individual gain.*
- *The Union's militancy and loose supervision by mukadams etc contribute towards indiscipline and absenteeism.*
- *Measures to increase the efficiency of mukadams, sweepers and loaders seem to be very difficult to implement because of the Union militancy and politicization of strikes.*

It is noteworthy that about 73% of the total expenditure of Solid Waste Management is spent on wages and salaries and hence it is crucial to achieve adequate performance of labour.

Public Relation Functions:

(a) Handling Complaints: There is a well-defined procedure for receiving and handling complaints. Complaints are replied to in writing after they have been attended to. Scheu and Coad (7) observed that record maintenance at the Central Office of the Municipal Corporation is considered inadequate for monitoring purposes.

(b) Publicity and Awareness Campaigns: No special campaigns for educating children or the general public had been undertaken in respect of Solid Waste although they have done so far conservation of water and planting more trees. At the time of the report prepared on the K-West Ward's Solid Waste Management by the authors, there appeared to be little interaction between Municipal Secondary School, the Heath Department and the SWMD.

The authors noted that "the lack of publicity and public awareness campaigns may one of the most significant in respect of SWM in Mumbai."

Finances:

The total annual expenditure on SWM in Mumbai was Rs. 1226.7 million in 1991, which represents approximately 14% of the total expenditure of the Corporation. In addition each ward receives Rs. 10 lakhs which is spent at the local elected councilors. In the K-west ward, not even a single item pertaining to SWM had been taken up by the councilors and the money was generally spent on public paths, water supply lighting, and provision of parks. This may reflect the low priority given to SWM by the elected representative (7). Punjwani (8) reported that in 1994-95, the Municipal Corporation spent 9.2 percent of the total Municipal budget on SWM which approximately Rs. 121 per capita per year for the entire city per se. However, a large proportion of expenditure was incurred on collection, mainly staff salaries (98% of total) and transportation, white a small proportion was used for purchase and maintenance of terms such as brooms, baskets. community bins and hard cards. The costs involved in SWM disposal in rupees per tonne were:

- Sweeping and Collection : Rs. 620
- Transport : Rs. 378
- Disposal : Rs. 8.95

The Corporation did not levy a SWM tax: charges levied for collector of market waste, from hotels and eating-houses were minimal. Provision of funds for SWM is made from the general funds of the Corporation

Conservancy Services:

The services provided include:

(i) Street sweeping (ii) Drain Cleaning (iii) Cleaning of public toilets.

However, public sector conservancy services are only provided to decided government and municipal slums. Conservancy services for the remaining categories are either almost non-existing or provided on a private contract basis. Out the 93 slums in K-West ward 68 are declared slums; 15 on government land, 7 on municipal land 46 on private land. In K-West ward in 1991, a population of only 4115 out of on estimated 5,50,000 were served by house to house collection.

Street sweeping is done in each beat (each SWM district is further sub-division into beats) by a pair of sweepers. There are about 262 beats in the ward and one beat represents approximately 3000-5000 sq. meters in busy areas such as main roads and 5000-10,000 sq. quieter areas/secondary roads.

Drain cleaning in residential localities and along small roads is carried out by 29 drain cleaners. Large drain cleaning is apparently the responsibility of the maintenance department It has been observed that drains in K-ward are not cleaned regularly and are often used for refuse disposal by the public. In low-income areas, the drains are clogged, causing flooding (7).

Cleaning of public toilets situated in low-income slums and on public land In certain private slums, private contractors render services. Services include cleaning and disinfecting of public toilets and removal of feces from public areas. In the past few years, there has been a move to construct pay and use toilets. In the Gilbert Hill–Gamdevi Dongri slum itself, Sulabh International has constructed a pay and use toilet. This NGO has numerous such facilities in various parts of the city including roadside facilities, near railway stations etc.

Primary Collection of Refuse and Disposal

Most of the middle and high-income families living in high-rise buildings/societies employ private collectors. This system of private collectors functions quite well and works independently of the public sector (7).

In slum areas, primary collection is usually carried out by the residents who carry their household waste to communal storage facilities or crude dumping areas in the locality. However. in some slum areas, some residents employ private sweepers for house – to – house collection paying Rs. 8/- per house per month. However. in slum areas, community storage facilities are inadequate and crude dumping areas are used. Most of the solid waste is collected either in open trucks. mostly operated by contractors and rented to the Corporation with a driver or by use of compactor trucks. The Municipal Corporation operates 4 landfill sites in different suburbs of the city.

Implements and Protective Clothing:

Different type of carts. baskets. wheelbarrows and brooms are used. However, the conservancy workers are not equipped with gloves. no boots are provided. A new uniform is issued to the conservancy staff every second year. However, less than 50 % of the employees wore uniform while on duty. Reasons given were that since only one uniform was provided per person. it does not allow for washing and repair.

Community Storage Facilities:

These include steel pipe sections, compactor trolleys. masonry facilities and refuse sheds (Figure 1).

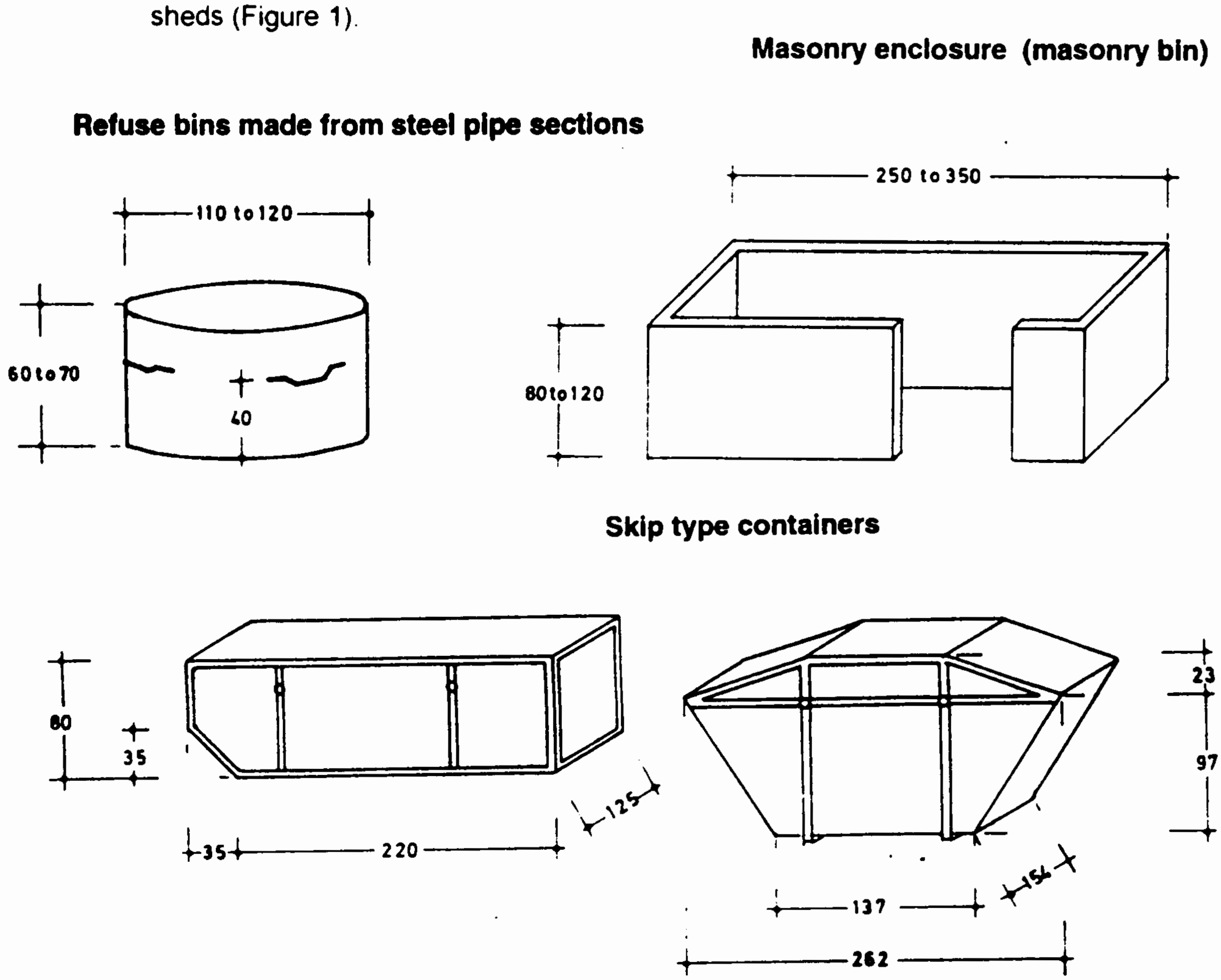


Figure 1. Community storage facilities available in K-West Ward.
(Source : Reference 7)

The total storage capacity is 295 m^3 in K West Ward and almost all of them are emptied once per day (7). The total solid waste generated in K-west is approximately 620 m^3 per day. The amount of solid waste collection is about 75% of that generated. Approximately twice the existing capacity is required to improve the refuse collection.

Recycling and Resource Recovery: (In the city)

Recycling of various materials from domestic, institutional and commercial sources is done. These include paper, cardboard, plastic, glass, metals, rags, gunny bags, tyres, bones, broken asbestos shell. Most of the material is gathered by rag pickers from bins, dumps, roads as well as dumping grounds. There is no reliable information about the segregation of recyclable items by municipal employees during motor loading.

In 1992, about 99.5 % of the solid waste collected in the city was disposed of at the 4 land fill sites. The remainder, 20 tonnes/day approximately was disposed of in ways of possibly gaining some economic benefit. These include vermiculture, pelletisation and composting by the Excel process. In addition, a mechanical compost plant had been installed and operated from December 1979 to May 1983, using an aerobic process. However, there were several factors which led to closure of the plant, such as high transport costs for the compost which farmers (customers) were unwilling to pay, only 46% produce could be sold presence of non-compostable materials like plastics, glass etc. and high moisture content of the garbage etc.

Processing of Solid Waste

Processing of a small quantity of waste is being carried out by the methods described herein:

1. A mechanized composting plant of 300 tonnes per day input capacity was set up in 1979. However, this was discontinued in the year 1983 due to the absence of buyers of compost on account of the high transportation cost.

2. Excel Industries Ltd. have set up in 1989, a pilot semi-mechanized compost plant at Andheri. The plant receives four trips of market waste (about 20 TDP) every day. The waste is stacked in different layers in windrows to which a microbial slurry is added and turning of the windrows is carried out by using front end loaders after three weeks. After six weeks, the established material is passed over a vibratory

screen and air separation unit to separate the inorganic and light material. The output is about 25-33 per cent of the input and is sold mainly for use in gardens. A plot of land (2317 m^2) has been allotted to them at a site in Malad (one of the Western suburbs) to process up to 500 TPD of refuse to produce 165 TPD of compost. The capital investment is expected to be Rs. 38.0 million. The operating cost is calculated to be Rs. 1000 per tonne and the product is expected to be sold at Rs. 1300 per tonne.

3. The Department of Science and Technology, Government of India has set up, in 1991 a pilot plant to process 150 tonnes of solid waste into 80 TPD of fuel pellets. The process involves reduction of moisture by sun drying, screening to remove sand, silt and soil, air separation of combustibles, followed by drying by hot gases, removal of metals, addition of binders to the waste, and its conversion to pellets for use in boilers as fuel. The fuel pellets have a calorific value of 3500-3600 kcal per kg. The cost of production and expected sale price of the pellets are Rs. 1000 per tonne and Rs. 1200 per tonne respectively. However, the present production is only two-three tonnes per day.

4. The Indian Institute of Technology, Bombay which has been processing three-fourth TPD of the campus waste by vermi composting for the last three years, has prepared a scheme to process 400 TPD of the waste from the Municipal Corporation of Mumbai by using this technology. The project involves a capital investment of Rs. 5.15 million on land development, civil works and equipment. The running costs are estimated to be Rs. 5.3 million in the first year and are expected to progressively increase to Rs. 15.9 million in the sixth year. The cost of production is estimated to be Rs. 800 per tonne (when raw material is supplied free of cost) and the wholesale price is expected to be Rs. 2,000 per tonne (market price – Rs. 4,000 per tonne). The payback period is anticipated to be four years. The plant was to commence (production from the third year onwards and reach the design capacity of 20,000 tonne per year of compost) at the end of five years.

THE GILBERT HILL – GAMDEVI DONGRI SLUM:

Pre Project Status and Need for the Project

The Gilbert Hill–Gamdevi Dongri slum is one of the largest slums in Mumbai city with a population exceeding 1,00,000.

The slum is situated on approximately 150 acres of land, much of it low-lying in the K-West Ward of Mumbai city. The settlement at Gilbert Hill–Gamdevi Dongri has been in existence for the last 50 years. It was recognized as a slum by the Mumbai Municipal Corporation in 1974 and like all other slums in Mumbai has been gradually witnessing a burgeoning in the number of its residents. The slum consists predominantly of Muslims (70–80 %). Almost half the homes are built on private land and in the early 90's, the environmental conditions of this slum were deplorable (Figure 2).

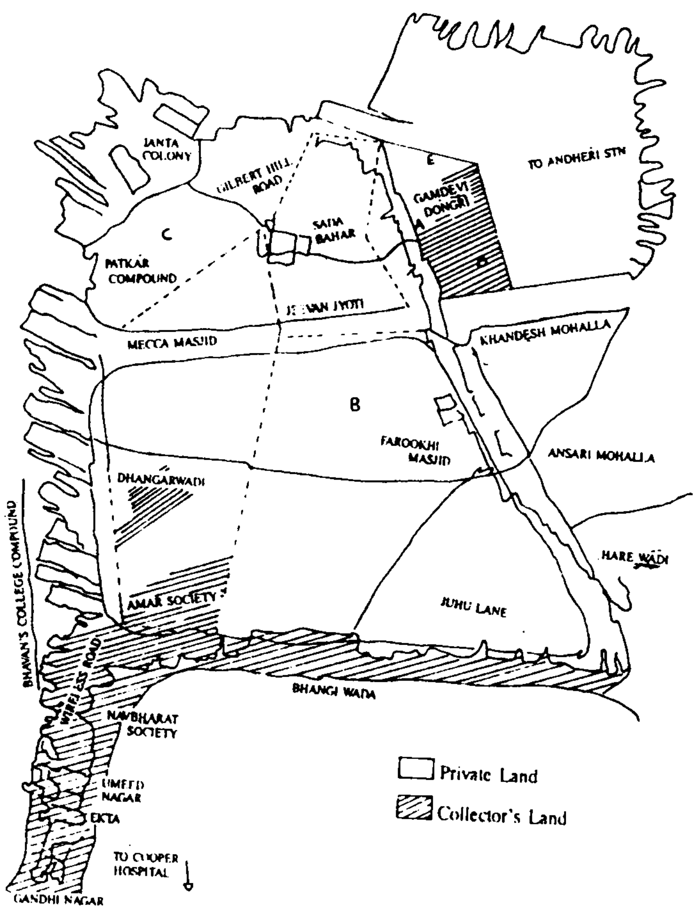


Figure 2. Gilbert Hill – Gamdevi Dongri Slum

Between 1990 and 1994, the Department of Postgraduate Studies and Research in Home Science, S.N.D.T. Women's University; was working with the Gilbert Hill slum community on an IDRC – supported project to improve the health and nutritional status. During this period, one of the most obvious and striking factors which was responsible for morbidity and poor nutritional status was the deplorable state of the environment. During this period, the project team was able to sensitize the slum dwellers and leaders about the sanitary conditions in their slum. However, in spite of verbal reiteration by these people, their attitudes and practices remained unchanged. A clean environment apparently was not the first priority for them. Scheu and Coad (7) observed the following in 1992, in a micro-survey of households in Gilbert Hill (Table 1).

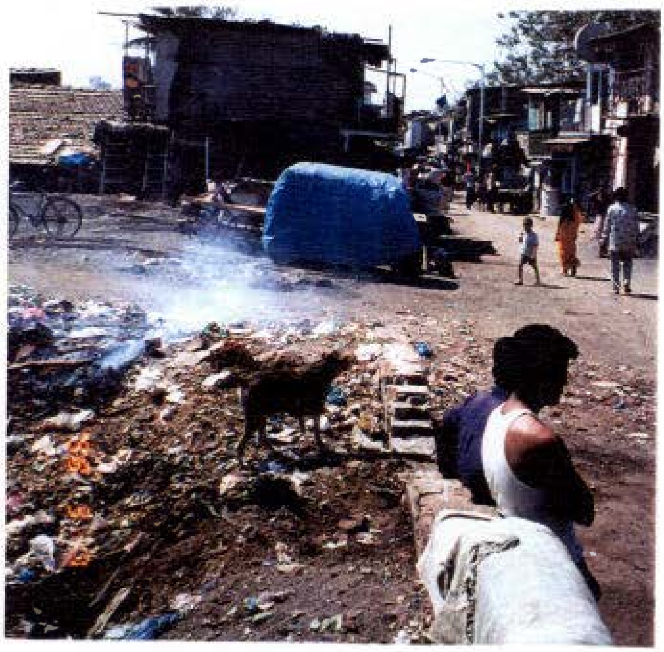
Table 1. Rank Neglected Services in the Locality in order of Importance

Priority	Water supply	Toilets	Flooding	Refuse	Roads	Electricity
First	2	22 (52 %)	3	9	7	0
Second	6	8	16 (38%)	8	4	2
Third	1	10	10	19(445)	3	0

Source: Scheu and Coad (7)

The answer showed that toilets were considered to be the most neglected service, the next priority being flooding. Refuse collection was given third priority.

Overall, the people had an apathetic attitude towards all respects of waste management. They considered it to be the duty of the local administration to ensure that refuse is removed, toilets are kept clean/functional. Yet their practice of handling/disposing of refuse was to dump it in the open drains outside the homes or in open areas nearby.

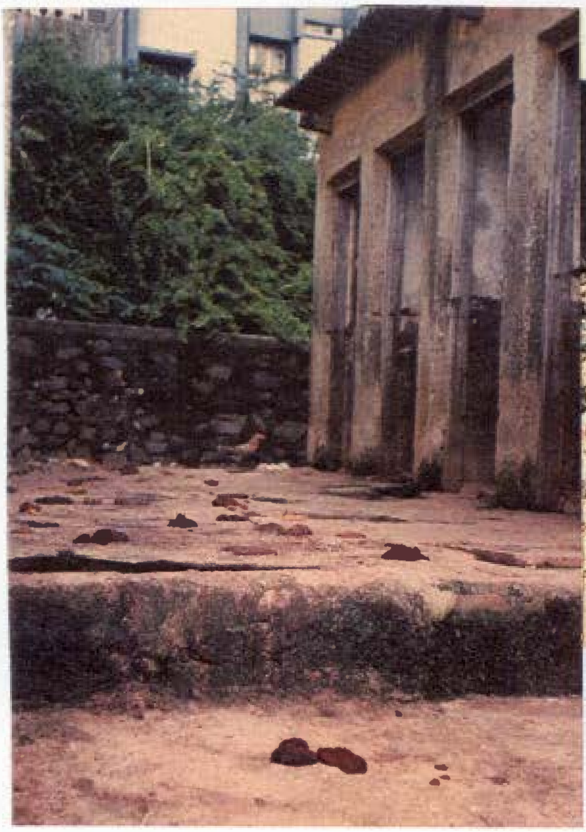


In 1992, Scheu and Coad (7) made further observations based on their survey:

- 44 % of the respondents stated the place where refuse is collected, was very dirty.
- 37 % stated that refuse is not removed.
- 16 % stated that the refuse bin is far away.

Toilets

Houses are usually without sanitary facilities. There were a total of 477 toilet seats, the ratio being 1 toilet for almost 200-250 persons. Cleaning in the toilet blocks was unsatisfactory and many of the toilets were blocked. Residents complained that the latrines were not cleaned regularly by the municipal staff. Children were frequently observed defecating in front of the toilets and close to the community bins.



Scheu and Coad (7) reported in Gilbert Hill that the following reasons were given by the respondents for children's non-use of toilets:

- Difficult for children to use - 60 %
- Parents do not like these places - 19 %
- No opinion - 21 %

The authors observed that another reason might be that parents do not show their children how to use the toilets properly. Children may feel uncomfortable because the toilets are very dark.

Feces around the toilets is generally removed by the halakhores, however, the workers do not have any protective gear including gloves. The feces was accumulated and dumped hear community refuse bins. The material was not removed by municipal trucks and thus accumulated. Children played around these community bins. Such a situation would obviously pose hazards leading to disease transmission.

Street Sweeping and Drain Cleaning

The drainage channel is approximately 9444 meters and the slum has 6272 sq. meters footpaths. Private contractors generally do street sweeping. However, drain cleaning appeared to be a dire need. Drain cleaning by the maintenance department was clearly, highly inadequate.

Many but not all of the lanes in the slum are concreted and open drains are provided. Residents themselves dump waste in the drains and refuse from nearby collection sites was carried by wind to the drains.

Since these drains were used for sewage disposal, the refuse in them would get wet, making it difficult to remove. In the monsoon, these clogged drains overflow and cause flooding. The slum also has a large drain, in which the residents dispose off garbage. In one of the pockets, Farooqi Masjid, large animal slaughter is carried out by a local slumlord and the bones etc. are disposed off in the large drain. Area residents are extremely scared of this individual and have not been able to make him stop this practice even after complaining to the police. The lanes in the slum are quite narrow, and permit limited or sometimes no access to wheelbarrows etc. Cleaning is therefore a very labour-intensive task. Cleaning was done occasionally but irregularly and the refuse was dumped near community bins.

Collection and Storage

The slums had some facilities for solid waste removal. Storage facilities for domestic refuse included 19 community bins of the pipe section type and 3 masonry enclosures. In 1995, at the beginning of this project, GIS data indicated the number of disposal facilities to be 19 (Figure 3). The municipal workforce of 45 persons consisted of 13 sweepers, 12 halalkhores (who clean toilets), 18 drain cleaners and 2 mukadams. Services are provided 6 days a week.

Figure 3. Location of Communal Solid Waste Collection Facilities in the slum

The capacity of the storage bins in Gilbert Hill was approximately 23.3 m^3, compared to an estimated requirement of approximately 56 m^3. The capacity available was therefore approximately 50 % of the requirement (7).

Overall therefore, the slum had highly inadequate solid waste removal facilities and services. The distances between community containers and the homes were relatively long. The distances varied from 40 meters to as much as 300 meters to the nearest community bins. Further the masonry bins were in despair. The community bins were all located on the main access roads and in the inner pockets, there were no disposal bins. This may be attributed to houses being constructed very close to each other, leaving little space for lanes per se.

A typical picture presented on entering the slum was informal and communal waste dumps overflowing with garbage, blocked drains, indiscriminate defecation including use of waste piles, scattering of this waste by animals.

Further overcrowding, unauthorized encroachment to the extent of construction of houses over drains have rendered it difficult to use approach roads, but more importantly, the lanes in the interior of the slum are so narrow that no vehicle or equipment can be used. Further, these lanes are not paved or concreted, are very uneven with potholes and obstructions and many are edged with open drains. The situation becomes worse in the monsoon season. Thus, almost half of the slum is inaccessible to vehicles including a handcart.

In 1992, before the initiation of this project; Scheu and Coad had the following suggestions:

- *Additional locations for community facilities for storage and regular removal of refuse need to be identified – The strategy should aim at spacing the facilities as close as possible, given the constraints of limited access.*
- *Considering that there seems to be a healthy attitude towards use of community bins, it is suggested that the public sector should employ private contractors to collect the refuse from their households and transport it to community bins.*
- *The masonry enclosures need to be replaced by community bins or contains. Since there would be limited number of locations available, larger capacity facilities like skips rather than pipe bins were recommended.*

The attitude of the people was typically to disclaim any ownership of the problems they faced and blaming the Corporation completely for all ills faced. In this context, the Project Team felt that there was a need not just to provided better facilities but to have a mechanism/strategy wherein the community would play an active role in managing their waste, rather than continue with their complete dependence on the urban local body. There was a great need for these slum dwellers to assume their civic responsibilities in their own area.

OBJECTIVES OF THE PROJECT

The overall goal was to design a community – based solid waste management system for Gilbert Hill with a potential for application to similar settlements in Mumbai.

Specifically the project addressed itself to:

A. **COPRICOL – Community-based Primary Collection System** – by which residents cooperate in collecting, wastes and delivering them to transfer points for collection by the municipal authority.

B. **COPRICOL – WRR:- Community-based Primary Collection System with source separation and Waste Reduction by recycling.** It was projected that waste reduction would be achieved by small scale composting in situ and the enhancement of trading of inorganic materials for recycling.

The project also addressed itself to the specific objectives:

A. ***Determination of community attitudes and perceptions of solid waste problems and their capabilities to co-operate with the various technological options and the organizational requirements including willingness to make financial contributions.***

B. ***Investigation of the nature and quantities of sold waste arising from households, shops, enterprises, stables etc. with particular reference to their suitability for local composting.***

C. ***Community education and training for solid waste management.***

D. ***Comparison of the technological options for COPRICOL and COPRICOL-WRR assessing costs and benefits, to pilot test the 2 systems and assess people's cooperation and capability to sustain the 2 systems.***

The project was designed to involve the active participation of the community in addressing the immediate needs of the various pockets in the slum. Simultaneously it was necessary to pursue the development of a community-based management capability to ensure environmental sanitation and hygiene through convergence with local municipal authority/ the urban local body and non-government organizations.

This report covers the period from May 1995 to January 1999 and describes the attempts, experiences and lessons learned during the study period.

STAGES/PHASES OF IMPLEMENTATION AND RESEARCH

The implementation of the project was planned to achieve the objectives as shown

PHASE I :	• Mapping – GIS Data, Secondary Data Collection • Quantitative Survey Of Attitudes And Practices • Focus Group Discussions On Current Situation
PHASE II :	• Participatory planning and Implementation of COPRICOL in 2 pockets • Sensitization and education of slum dwellers • Motivating Community to look at SWM holistically and address all aspects themselves • Greening to be initiated • Physical and Chemical Analysis of Garbage • Morbidity Survey
PHASE III :	• Opinion about COPRICOL system • Expansion of COPRICOL to other pockets • Initiation of COPRICOL- WRR • Education and Sensitization
PHASE IV :	• Expansion of COPRICOL for coverage of entire slum • COPRICOL – WRR in selected areas wherever space available • Greening • Urban Agriculture/City farming • Education and Sensitization • Ensuring self-sustainability • Morbidity and Post-Intervention Survey

Phase I: Attitudes and Practices of the Slum Dwellers

At the start of the project, in May 1995, a quantitative survey was conducted using a semi-structured interview schedule (Appendix I). The schedule was first pre-tested on 72 families. Educated adolescent girls in the community were trained to collect the data.

The slum was divided into six zones and 8 to 10 percent of the families residing in each zone were included (Table 2).

Table 2: Number of Families surveyed from the Six Zones

Zones	Area	No. of Families
1.	Wireless Road and Bhavan's College	115
2.	Bhangiwada and Juhu Galli	100
3.	Khandesh Mohalla, Ansari Mohalla and Sada Bahar	97
4.	Dhangarwadi and Macca Masjid	75
5.	Janta Colony	136
6.	Gamdevi Dongri	240

Economic Status and Literacy

About three-fourths of the families (73.8 %) had income ranging from Rs. 1000 to 5000 per month; 22 per cent of the families earned less than Rs. 1000 per month and only 4 % had monthly incomes exceeding Rs. 5000. At least half the males and females were illiterate (Figure 4).

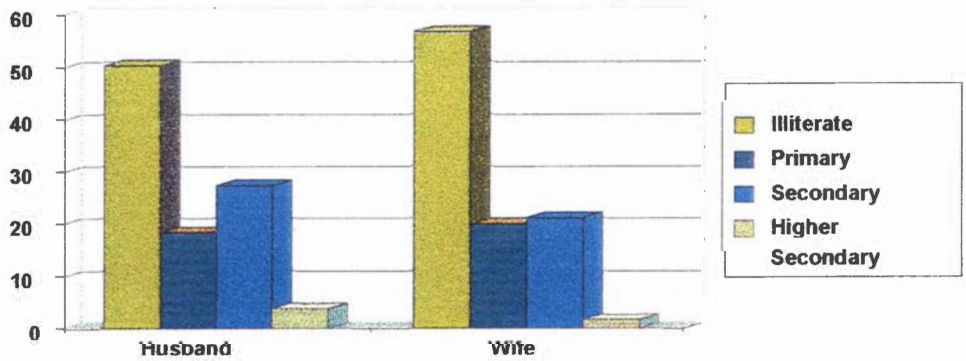


Figure 4. Educational Status of Husband and Wife in the Families surveyed

Garbage Disposal

More than three-fourth families (77.3 %) accumulated the garbage in the house before disposal. However, 22.7 % threw the solid waste as soon as it is generated into the open drains adjoining the house or in the nearby open spaces. The decision-maker regarding garbage collection varied, but in almost two-thirds (56.6 %) of wives took the decision regarding garbage collection (Table 3).

Table 3. Member of Household taking Decisions about Garbage Disposal

Decision maker	Percent families
Husband	8.3
Wife	56.6
Joint (Husband and Wife)	2.2
Mother/Mother-in-law	7.8
Daughter/ Daughter-in-law	6.6
Father/Father-in-law	0.3
Son	2.8
Anyone	15.4

Almost half the families collected garbage in polythene bags or plastic containers (Figure 5).

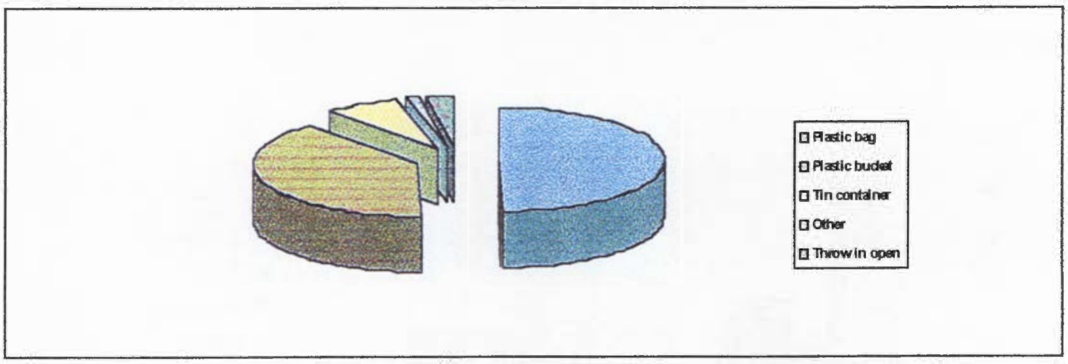


Figure 5. Materials / Containers used for garbage disposal

More than three-fourths of women who stated that the solid waste is thrown in nearby open areas or in the drains, said they do so because they have no place inside the house to store wet/organic garbage. Hence every time they cook/whenever solid waste is generated, it is thrown outside.

A little more than ten percent (14.2 %) separate the solid waste. Separation habits appeared to be influenced by educational level. (Figure 6).

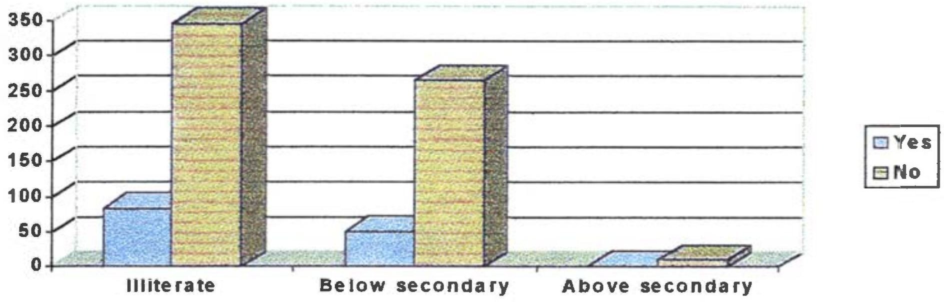


Figure 6. Educational level of Women and Separation of Solid Waste.

Almost two-thirds of respondents stated that the total amount of solid waste discarded per day was less than 2 kg, according to their estimate.

Type of solid waste discarded/thrown by families included both organic and inorganic waste (Figure 7).

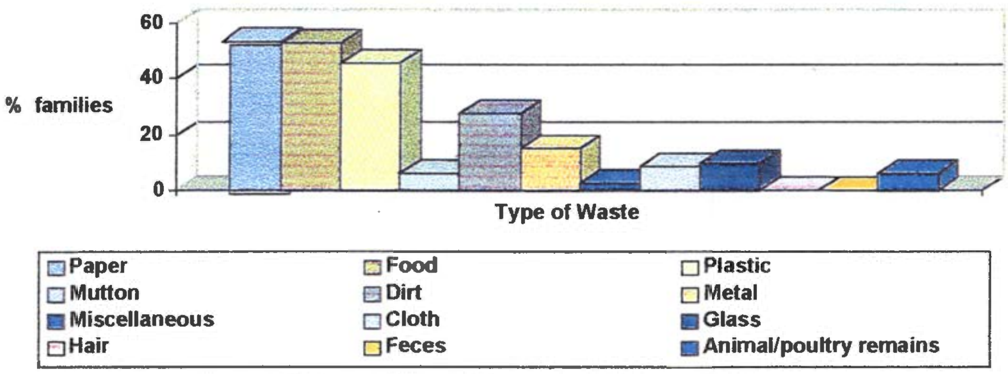


Figure 7. Type of Waste Generated in Households

A little more than half the families (59.1 %) used the communal bins provided by the Municipal Corporation for disposing off the waste. However, almost forty percent dumped the solid waste daily either in the nearby drains or nearby open spaces or on the road. The problem of the resultant clogged drains was exacerbated by irregular services and prolonged delays in lifting of the solid waste by the Corporation employees. Further the number of receptacles were too far for many of the families as well as being highly inadequate in number. Most of the receptacles were generally in a broken and dilapidated condition.

Only 53.1 % households had access to the communal bins provided by the Corporation and 58.9 % respondents used these. As many as 41.1 % respondents could not use the bins since they stated that they were not located in a spot convenient for their use.

Satisfaction with Services for SWM

The Municipal Corporation was largely identified (71.7 % respondents) as the organization mainly responsible for collection and disposal of waste from their slum. However, 19.8 % were unaware about who collects and disposes of the garbage.

Only half (55.3 %) of the respondents expressed satisfaction regarding the Corporation's services. The reasons for dissatisfaction were:

- Irregularity of work
- Ineffective, inefficient and improper ways of cleaning.

This condition prevailed in spite of 37.8 % of households paying money to the Municipal conservancy workers to clean the area. The payment varied among families from Rs. 2 to Rs. 15. However, it must be noted that these payments occurred in sporadic fashion and were not done on a regular basis. About half (55.3 %) expressed satisfaction regarding the quality of services they paid for.

About two-thirds (60.9 %) of residents felt the need to improve the conditions of the communal dumping bins and their immediate surroundings. However, 40 % appeared to be indifferent to the sanitary conditions at the dumping sites. One of the main reasons for this state is that the slum dwellers throw the solid waste from a distance, more often than not missing the bin itself. Thus, most of the solid waste was generally scattered around the open area surrounding the communal bins.

The respondents were asked whether residents use the communal bin in a proper manner (Table 4).

Table 4. Opinion of Respondents whether Communal Waste Bin is used properly.

Response	% Respondents
Yes	35.5
No	40.8
Do not know	23.8

For those who responded 'do not know' the communal bin may have been located too far from their home and may have been non-users.

During focus group discussions, women stated that the disposal habits of the residents were largely responsible for this problem, because people throw the garbage from a distance and more often than not, it falls outside the bin. The garbage is scattered further by stray animals searching for food and by rag pickers. The rag pickers generally come to pick up recyclable material early in the morning or late hours of the evening. The women and all residents require the area to be very clean. However, they were not able to perceive that the problem was created by the disposal habits of all the residents in each pocket. Each family generates a small amount of solid refuse but their way of disposal and the sheer numbers in terms of population would lead to a highly dissatisfying condition around the communal bin. Further the onus for maintaining cleanliness in their opinion was the Corporation's and they did not perceive how the slum residents created/exacerbated the problem.

In many of the discussions, women themselves emphasized the need to educate the community about adopting better habits for solid waste disposal.

Scheu and Coad (7) observed the following in their study:

Please think about the place where most people in your locality bring their refuse and choose the most serious problem :

- Refuse is not removed - 37 %
- Place is very dirty - 44 %
- Place is far away - 16 %

There are relatively long distances between community bins/containers. Along the main access road, the distance on an average was 120 meters ranging from 40 to as much

250 meters. in some areas, residents had to walk as much as 300 meters to dispose of garbage.

Respondents were asked whether they faced any problems related to solid waste specially during the monsoon. Their responses are summarized in Figure 8.

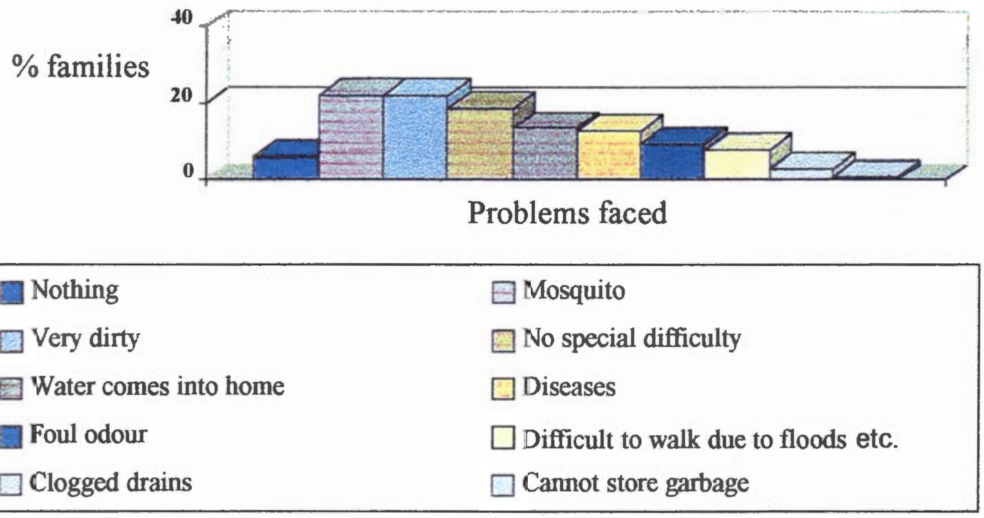


Figure 8. Difficulties faced in Monsoons due to Solid Waste

Awareness about handling the waste

Although 70.8 % respondents knew that the Corporation lifts and transports solid waste out of the slum; they were not aware, how it is handled thereafter. Their knowledge about disposal of waste from toilets was very poor as is shown by their responses.

How is the waste of the toilets handled?

Nothing is done	4.2
Enters the gutters/drains	65.7
Collected by sweepers	4.3
Do not know	25.8

Flooding, stagnation of water and blocked drains are a perennial problem in the slum. Yet the percentage of people listing difficulties faced during the rains was not very high. The improper and/or lack of disposal of solid waste contribute greatly to mosquito breeding. Scheu and Coad (7) asked their respondents about influence of disease vectors (Table 5).

Table 5: Please select the most Significant Nuisance in your Locality from the following

	% respondents
Flies	2
Mosquitoes	77
Rats	21

Mosquitoes were considered the most significant nuisance.

In the present study, respondents were asked whether due to solid waste lying around, the population faced any health hazards. Two-thirds felt that the dirty surroundings were mainly responsible for causing and spreading malaria (Figure 9).

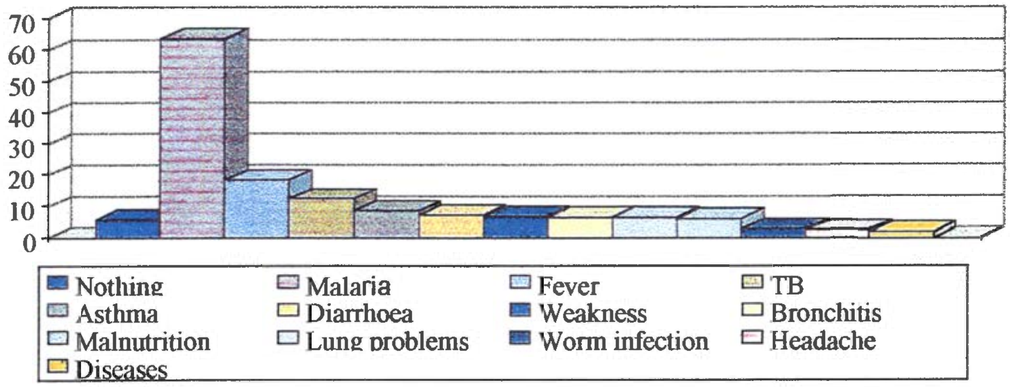


Figure 9. Perception of Slum Women about effect of Solid Waste on Health

Only about 2/3 of respondents felt that poor waste disposal habits results in environmental pollution (Figure 10).

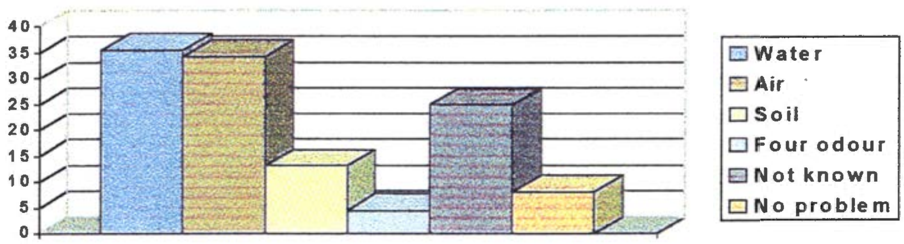


Figure 10. Type of Pollution

Besides solid waste, respondents were asked for suggestions to improve the SWM system. About 1/3rd of the respondents (30.2 %) were indifferent and did not give any suggestions. The responses given by the others are summarized in Table 6.

Table 6. : Suggestions for Improvement of SWM in Gilbert Hill.

Suggestion	% Responses
Trucks should come daily	39.6
Area can be kept clean	18.8
Bins should be provided	17.4
Nothing need be done	10.9
Sweepers should be punctual	8.1
Many things are required	3.0
Tree plantation	0.8
Create awareness	0.6
Drains should be kept clean	0.6
Pay for clean-up services	0.2

Scheu and Coad (7) obtained the following response in their survey:

	Good	Fair	Poor
• What do you think of sharing a community bin with several families if it is emptied daily	84	5	12

Toilet Facilities

There are 477 toilets for the entire slum. Of the 763 families surveyed, 718 used the public sanitary latrines. Only 4.5 % possessed a septic latrine in their homes and the rest used open areas for toilet purposes. Thus the ratio is, 1 toilet per 252 persons. Even the existing toilets are not in good conditions, many of which are blocked and in disrepair. Since children cannot wait in long queues, they generally use open areas near the home or toilet, the roadside or the open drains.

Scheu and Coad (7) asked about the possibility of a house-to-house collection facility:

	Good	Fair	Bad
• What do you think about the idea of a scavenger collecting refuse from your house everyday.	84 %	5 %	12 %
• How should the scavenger collect refuse.	63 %	14 %	23 %

Since the residents were more dissatisfied than satisfied with the disposal of refuse, they were asked in the present study whether they needed these services on a regular basis. 14.8 % of respondents did not feel the need.

Almost three-fourths of families were willing to pay for the services through a monetary contribution, one-fifth was prepared to give their time and help in implementation of the scheme.

Considerable proportions of residents were quite apathetic since they felt, nothing needs to be done to improve the environment. (Table 7).

Table 7. Responses to What would You do to improve the Environment near your Home.

Need more space	27.1
Need more sunlight	28.6
Plants	35.7
Nothing	24.3

In response to the question:
"What would you do to improve, the environment in the community?" Most families (90%) felt keeping it clean was the solution, and 18.6 % felt the need for greening. Respondents were asked whether greening should be done in the limited open spaces within the slum. A little less than half (45.2 %) gave no response. Among the remaining various suggestions were given for use of the small open areas (Table 8).

Table 8. Suggestions given for Use of Open Space.

• Plant flowers make a garden	15.9
• Open areas should be left open with grass planted	15.9
• Plant fruits and vegetables	11.0
• Use for children as play areas	47.7
• Use for composting	9.0

The lack of space for children to play, probably was the reason for almost half of the residents' suggestion to create a playground.

Among these families, about one-third stated that they do not get sunlight within the house. Respondents were asked whether they would be interested in growing plants. About 1/3 were not interested. Among those who were interested, almost half, stated they have plants most of them for decoration. Evergreens, flowering plants as well as creepers were planted.

The baseline data pointed to the need for addressing the problem of solid waste. During focus group discussions two issues emerged clearly:

- **On the whole, people felt the need for better environmental sanitation but felt the problem was more because the Corporation's services left a lot to be desired. They did not associate completely, their own disposal habits with the build up of solid waste in the area and felt the onus of responsibility was the Corporation's to keep the area clean.**
- **They did not have any solutions (large-scale) to keep the slum clean, nor did they have either the resources or know-how for management of solid waste.**

Prior to implementation of the project therefore the following issues were considered critical and pivotal for revolving the strategy:

- **The direction of approach for managing waste should be community – oriented. The basic need was to involve the community and to motivate them to play an active role in managing their waste.**

- **It was necessary to wean them away from their complete dependence on the local authorities especially in terms of managing a programme.**

- **To make the slum community understand solid waste management in its various dimensions i.e. environmental, social health and economic.**

When initiatives are introduced by the Municipal Corporation or by a local non-governmental organization, issues such as scale of activities and programme sustainability are of tremendous concern. If the local urban body/NGO remains the implementing agency in the long-term, the programme will remain a demonstration programme. Whereas, for the momentum to be sustained and converted into a movement for large-scale sustainable implementation, there is a need for withdrawal of the external agency. It was therefore deemed vital, that from the beginning of the project, the responsibility should be assumed by the local residents in order for it to be effective, and to sustain and if possible expand it.

In this project therefore, it was evident that if sustainable change was to be achieved, mere physical removal of waste would not help as it was vital to make the community realize and accept its own role in solid waste management issues.

Along with these, during focus group discussions, it was highlighted by women that toilet facilities also need to be addressed. For this, the team had to facilitate and foster liaison between the slum residents and the local authorities.

Developing and Establishing the Solid Waste Management System

Besides improving the existing systems, reduction of waste at source through segregation was proposed.

Since the entire slum has more than 10,000 families, it was decided to initiate the project, in the first year, in 2 pockets: Gamdevi Dongri and Wireless Road, covering approximately 3000 families. The system planned in this phase was to:

- To reduce waste at source through segregation.
- To set up an independent and financially self-sustainable system for waste collection.
- Final removal of waste would require services from the Municipality.

Thus the COPRICOL was mooted in order to evolve a feasible mechanism, the key aspect being public participation.

Evolving the Mechanism for COPRICOL

Meetings were organized with women residents of the 2 selected pockets where the scheme would be initiated. Between June–July 1995, 43 meetings were held. Dialogues were held regarding the overall goal of the project and suggestions were invited from participants. Based on these, decisions were made regarding the COPRICOL. The following information was obtained through the group discussions:

- None of the families/women separated solid waste except for saleable material.
- All women who participated in the discussions were willing to try separating the solid waste.
- About 6-8 % women were not interested in attending the discussions and meetings.
- Approximately 18 % women threw garbage in drains or on the roadside.
- Most women (90 %) were willing to pay for containers to store the garbage at household level as well as to pay for the COPRICOL per se.
- Approximately half i.e. 50 % were willing to participate in implementation, in terms of supervising the garbage collectors.

Several problems faced by the households were listed and the women opined that it would be necessary for the project team to address on a priority basis:

- Dire need for new additional toilets
- Repair and maintenance of available toilets
- Need to repair/rebuild communal bins.
- Sensitization of community members
- Solid waste from hotels
- Rodent menace
- Disposal of children's feces

The key features of the COPRICOL finalized in consultation with the community women were:

- **Each family should contribute for solid waste collection to sustain the system after IDRC support ceases.**
- **The containers for storing garbage at household level should not be provided free. A nominal amount of Rs. 2.50 per container was to be charged, since the women felt that only then would the community members value the container and use it appropriately.**
- **A supervisor would be elected/nominated by the women. The supervisor would monitor and supervise the house-to-house solid waste collection as well as the money to be paid to the collectors.**

Accordingly, 2 containers were distributed to each household. Children in the community were involved in the distribution, during which women were explained the need to separate 'wet' and 'dry' solid waste.

Along with the containers, each family was given a small handout which depicted what was 'wet'/organic and 'dry'/inorganic waste.

Further, during the first 8 months of the COPRICOL, the project staff personally went door-to-door to explain to the resident, and ensure that they separate the solid waste.

- Each family was supposed to pay Rs. 2/- so that each collector would receive approximately Rs. 1000/- for collecting the solid waste from 500 households.

The scheme was started with a formal inauguration of the project on September 5, 1995. For the inauguration several key officials were invited: Mr. Satish Tripathi, the Secretary to the Governor of Maharashtra State, the Engineers of the Ward Office, representatives of another agency working on creating environmental awareness and from Sulabh International as well as Excel Industries.

In order to sensitize the people from the slum an exhibition was organized. The issues were represented through charts and posters on the current situation of waste disposal in their slums and the hazards posed for health as well as environmental degradation and the role of the community in solving these problems. Also the preschool education teachers with the children performed a street play conveying the importance of a cleaner and greener community. To mark the beginning of the project, some women leaders were given the plastic bins by the Chief Guest.

The Municipal Engineer shared with the community women, information on a similar garbage collection initiative and the mechanism of operation in a slum situated in K (West) ward in the same suburb.

The COPRICOL was started in the 2 pockets covering 3000 households after:

1. Mapping of routes of garbage collectors, with community women leaders and the garbage collectors themselves.
2. Orientation to the garbage collectors and supervisors about the project objectives and COPRICOL.
3. Location of vacant available space for storing the garbage collection trolleys.
4. Workers/collectors were needed for COPRICOL. For this, rag picker communities in the nearby suburbs were visited. However, these people were not interested since they felt that their earnings through their own occupation far exceeded what would accrue to them from their project.

During the dustbin distribution drive, some of the local sweepers employed by the BMC were present. They were impressed by the proposed scheme and volunteered to send their unemployed brothers/relatives/friends for this work. Thereafter, wherever possible, the contract was given to local residents to provide them a means of income.

Each collector was paid Rs. 2 per family and covered approximately 500 households in a period of 2 - 3 hours daily.

It had been finalized during meetings with the community women that each family be charged a monthly contribution of Rs. 2/- for waste clearance. This money would be the remuneration for the garbage collector.

In addition, a supervisor was elected from among the women. Each supervisor looked after 200–300 households and was paid an honorarium of Rs. 300 monthly from the project funds. In addition, resident community volunteers (RCV) each of whom represented 20–25 households were asked to monitor the scheme in their respective groups of 20–25 families.

5. The project team with the local RCVs and through involving school children distributed waste collection containers. Women were explained the importance of separating the organic and inorganic waste and to use the dustbins. In order to reinforce the message, a leaflet containing drawings/pictures of which materials constitute dry/ inorganic and wet/organic garbage was given to each housewife. In addition, posters bearing the same message were put up in various thoroughfares of the slum.

For the COPRICOL, each collector was provided a plastic trolley and gloves. In addition, each collector was provided rubber knee-high boots (gum boots) and a raincoat for the monsoons. However, most of the collectors did not use raincoats and boots, since they were not used to wearing these and they found it an impediment in their collection activities.

Also, rakes and shovels were provided to the collectors in order to enable them to collect the scattered solid waste in the communal bin. In addition, each worker was given an identity card.

The supervisors were generally RCVs and their role was:

(i) to ensure that the collector picked up the garbage from all houses

(ii) to collect the monthly contribution from the residents

(iii) to motivate and counsel the women to segregate garbage

(iv) to liaise with the other RCVs and NHCs and report on the COPRICOL status during the NHC meetings

(v) to liaise with the local leaders, local Municipal officials and elected representatives

At the beginning, the housewives' response to segregation of solid waste at household level was poor. Hence, the project team began a door-to-door campaign, accompanying the garbage collector in order to persuade and motivate women to segregate the garbage. Gradually, over a period of 2-3 months, women began to segregate the garbage.

Although the implementation of COPRICOL was started with approximately 3000 families in September 1995, in order to achieve impact, it was essential to expand the COPRICOL to other pockets, which housed another 8000 to 10000 families. During the door-to-door visits, it was observed that either dry/wet garbage was discarded in plastic bags and housewives were not using both the containers supplied to them through project funds. Therefore, a survey was conducted on 768 families selected by simple random sampling, in order to assess how the second dustbin was used. The survey revealed that most of the families were using the dustbin for other purposes, such as:

Purpose	% families
• Filling water	3.4
• Washing	0.5
• Storing grains	1.9
• Plant holders	2.0
• Not used for solid waste for any other purpose	21.4

As many as 72.6 % of participating families did not use the second receptacle. These findings were discussed with the Neighbourhood Committees in Wireless Road and the Gamdevi Dongri Mahila Mandal. Since the receptacles were provided at a highly subsidized rate and almost 85 % of the cost was borne by the project, the community workers suggested that families should be provided only one receptacle through the project. They suggested that the housewives should store dry waste in plastic bags as was the practice in the slum.

Expanding COPRICOL's Coverage:

In January 1996, residents of the pocket adjoining Gamdevi Dongri, (members of Gulshan Welfare Society) requested the project team to start the solid waste collection system in this pocket. Several meetings were held in several mohallas of this pocket, which houses about 1500 families with the help of some society members, local leaders and the Neighbourhood Committees (NHC) of the UBSP. By July 1996, the COPRICOL was gradually expanded, covering 6745 families, with eleven collectors working for the scheme.

The number of families covered in various pockets up to July 1996 is shown in the map. The COPRICOL was yet to be started in the pockets of Dhangarwadi, Bhavan's College, Compound, Khandesh Mohalla, Ansari Mohalla, Juhu Galli and Jaisingh chawl covering more than 2000 families. The reasons for not starting the COPRICOL in these areas were the extremely narrow lanes, no communal waste collection bins in these vicinities, lack of space and poor condition of existing paved roads or unpaved paths which made handling of the trolleys in these pockets almost impossible. Also families in some central pockets namely Wadarwada, Khandesh Mohalla, Ansari Mohalla were not willing to participate in the primary collection scheme (Figure 2).

In 1997, NHCs in Bhavan's College Compound and Dhangarwadi as well as the Navrang pocket in Gamdevi Dongri were formed. These NHCs were keenly interested in having the COPRICOL in their area. In the other pockets Wadarwada, Afsa Masjid, Daulat Khan ki Chawl, Khandesh Mohalla and Ansari Mohalla several meetings were held with women, local leaders and RCVs and they were persuaded to try the COPRICOL. Thus by end of 1997, approximately 10,000 families were participating with the exception of around 800 families in Bhangiwada, Juhu Galli, Jaisingh chawl and 250 families in Sada Bahar.

At this juncture, all of the UBSP, NHCs and Community Organizers were involved in the day-to-day implementation as well as monitoring the project. The NHCs requested the SNDT Teams (IDRC and UBSP) to help them for repair and/or construction of access roads that would facilitate the solid waste collection in the COPRICOL.

Earlier at the initiation of the project, the community had prioritized repair and construction of communal waste bins for action.

Hence, the IDRC and UBSP project teams and the NHCs of all pockets held a meeting. It was mooted by SNDT that since the project funds could not be extended to road repairs and construction, SNDT would undertake the provision of the communal dustbins. For the latter, the Institution (SNDT) and the project teams would undertake

(a) advocacy with the Municipal Corporation, elected representatives and voluntary organizations and

(b) help the NHCs (in terms of guidance and capacity-building) to avail of services provided by the Municipal Corporation for road repair and/or construction.

Thus, as the COPRICOL became operational, the project team had to pay attention to the state of the communal solid waste collection bins. After dialogues with the officials in the local ward office, it was perceived that SNDT would have to undertake the repair and in several cases, the reconstruction of these facilities. Accordingly, seven of the bins which were most in disrepair were reconstructed through project funds after obtaining the "no objection"/permission from the local ward officials.

In all cases, the contract for construction work was awarded to local construction workers and the community workers and the women supervisors participating in the COPRICOL undertook supervision of the work.

Monitoring the COPRICOL

Monitoring of the system and daily supervision were required. Supervision was done on a daily basis by the paid supervisors. A monitoring mechanism was set up at 2 levels of the Community-based structure:

(a) Each NHC would monitor the COPRICOL in their respective pockets of 200 – 300 families. This would include:

- The activities i.e. attendance, regularity and performance of the garbage collector(s) and the supervisor respectively.
- The practices of individual households to prevent them from dumping the solid waste indiscriminately.
- Monthly collection of contribution from families which would affect the sustainability of the COPRICOL.

The Community Organizers and Project Officer were asked to work in coordination with the UBSP staff. It was also decided that environmental sanitation should be discussed as a priority issue at each NHC meeting, which was held weekly.

Monthly review meetings would be held with all garbage collectors, IDRC and UBSP project team members and the representatives of each NHC. These meetings wee initiated to solve the local mohalla level problems as early as possible and to address common issues, take decisions jointly as well as share experiences and ensure smooth implementation of the COPRICOL.

These aspects as well as others related to solid waste management and environmental sanitation would be reviewed at the weekly NHC meeting held with the UBSP Community Organizer.

These weekly meetings with the NHCs and monthly meetings at whole slum level helped to:

1. Sort out problems faced in terms of irregular attendance of many collectors
2. Brought up new issues on SWM such as some NHCs volunteering to maintain their communal toilets through pay and use mechanism.
3. Discuss and work on solutions related to cleaning of drains and gutters on a regular basis.

At the weekly meetings and for follow up the UBSP Community Organizers guided the NHCs on availing of services from the Municipal Corporation and elected councillors on several issues related to SWM. Ultimately through the persistence of the NHCs and the advocacy done by the IDRC project team with these officials and leaders, there were improvements in several pockets in 1997 and 1998 (Figure 11).

- New toilet blocks constructed in Wireless Road, Gamdevi Dongri, Sada Bahar, Patkar Compound and Gilbert Hill.
- New and differently designed communal facilities for solid waste disposal/collection.
- Repair of toilets in several pockets.
- Constructions of 2 major access roads in Patkar Compound and Juhu Galli.

The NHCs independently began to approach the Municipal Corporation with requests for garbage pick-up, cleaning of gutters, toilets etc. and availed of the Corporation's services.

The partnership approach adopted by SNDT and the support provided by the project teams and the positive response and recognition from the Municipal officials especially the Additional Municipal Commissioner, Mr. Gaikwad, gave the NHCs tremendous amount of self-esteem. These inputs also gave them an impetus to tackle varied issues on their own, representing the possibility of their sustaining their activities to improve quality of life in their areas.

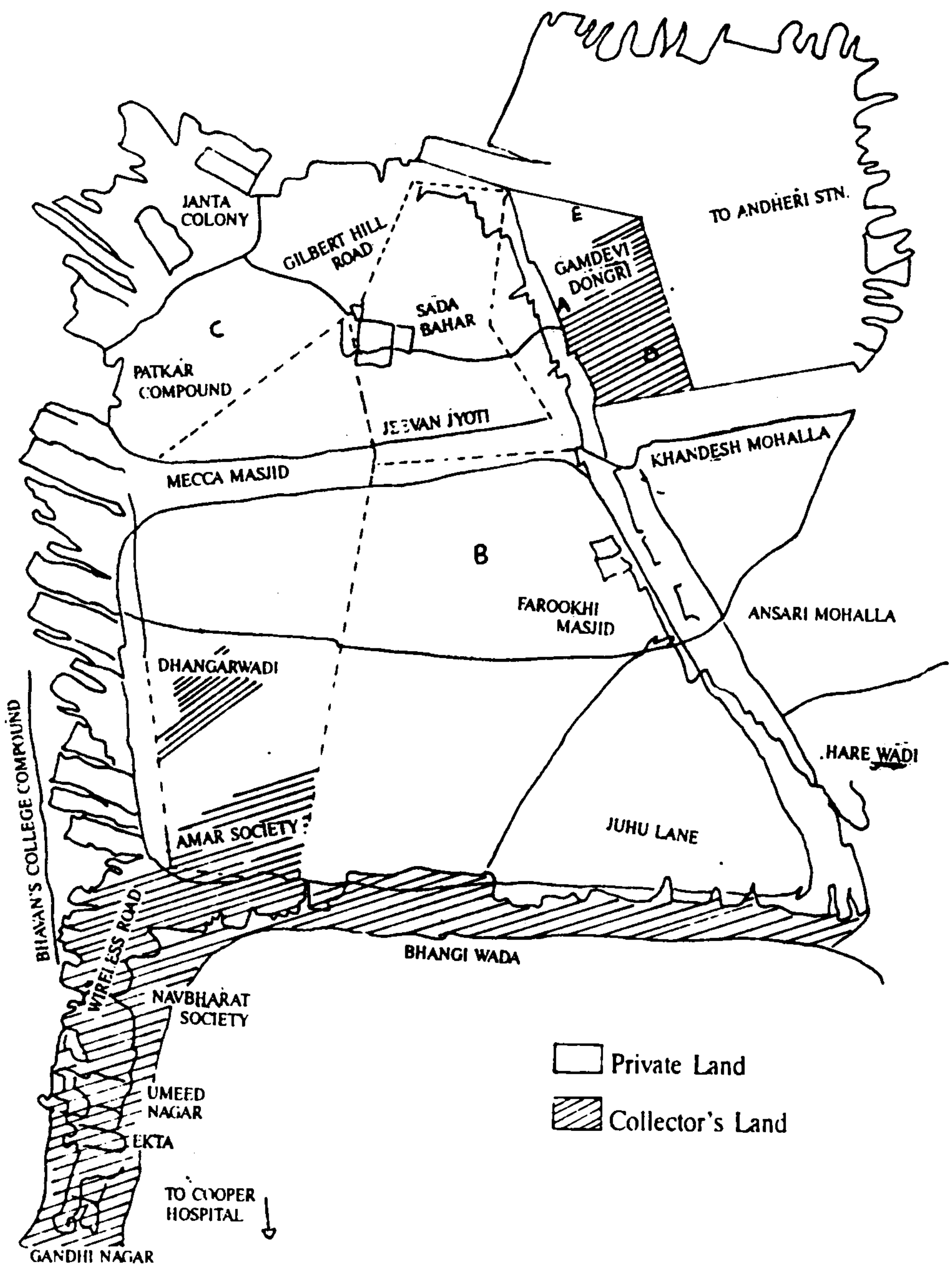


Figure 11. Additional/New Facilities made available to Slum Residents through the Project.

Simultaneously the project teams (UBSP and IDRC) through advocacy were able to obtain services from the local Ward Office of the Municipal Corporation in 3 key areas from 3 line departments:

CONVERGENCE FOR FACILITATING COPRICOL

(I) From the Solid Waste Management Department

- **Collection of garbage on a regular basis**
- **Cleaning up of Drains and Gutters**

(II) From the Maintenance Department

- **Repair of Roads**
- **Cleaning and Covering of Drains**
- **Tree guards**

(III) Pest Control Department

- **Rodent (rat) control**

(IV) Garden Department

- **Technical advice**
- **Plant/shrubs at concessional rates.**

From the beginning of the COPRICOL, the money collections were less than the amount to be paid to the eleven garbage collectors (Table 9).

Table 9. : Total Contribution by Residents vis-à-vis the Salaries due to Garbage Collection in the COPRICOL.

Total Contribution from all pockets (Rs./year)			Salaries
1996	**1997**	**1998**	**(Rs./year)**
50,260	38,805	51,183	1,98,000

Consequently, after discussing the issue of financial stability with the residents and the NHCs, it was decided to raise the contribution to Rs 3 per family per month. Hence in mid –1997, the contribution in most pockets was raised to Rs 3/-. However in some pockets, the collectors could not take the trolleys in the narrow lanes and in one pocket of Gamdevi Dongri, the slope of the paths was an added difficulty. In these pockets, the SNDT team mooted that residents should contribute Rs 5 per family per month. In almost all pockets, 2 – 3 meetings with each group of residents was required in order to convince them. Overall, the attitude of residents was that external agents such as the Municipal Corporation and/or SNDT should provide these services free of cost. Although the COPRICOL coverage had extended to cover 10,000 families, frequent complaints were made to the SNDT team that the collectors were irregular and did not cover all families.

In 1997 (Year III of the project), a door-to door survey was conducted in the slum, to determine the status of COPRICOL. This was undertaken to obtain quantitative information on 3 aspects:

- Percentage of families who pay for the collector's services.
- Amount of money paid.
- Regularity of the collector.

The survey was undertaken to know whether the non-payment of monthly contributions could be traced to irregularity of the collector. Also, at this juncture (October 1997) although most families in the pockets covered availed of the COPRICOL services, the money collected was very meager and collectors had to be paid from project funds continuation of the COPRICOL. The observations of the survey are summarized in Table 10.

Table 10: Percent Families reporting Regularity of Garbage Collector

Area	No. of Families	Regular	Irregular	Absent
Gamdevi Dongri	1894	45.3	45.0	9.7
Macca Masjid	369	36.4	15.4	48.2
Farooqi Masjid	295	66.1	9.8	24.1
Gilbert Hill	458	45.2	26.6	28.2
Sada Bahar	50	0	70.0	30.0
Juhu Lane/Galli	148	29.7	12.8	57.5
Wadarwada	275	49.8	20.0	30.2
Dhangarwadi	151	41.1	58.9	0
Janata Colony	1444	31.6	60.8	7.6
Khandesh Mohalla	207	59.4	12.6	28.0
Patkar Compound	633	0.6	0	99.4

Approximately, half of the slum families were covered (n = 5924). The irregular attendance / incomplete coverage of families on a daily basis partly explained the poor money collections. Regularity of attendance varied from nil to only 66 % of families reporting. When families reported that the collector was absent, it meant that although collectors were supposed to collect the solid waste, they did not go to all areas within a single pocket. The percent families remaining unreached, varied from nil to as much as 99.4 % in Patkar Compound.

The percentage of families not contributing at all varied considerably (Table 11). Monthly contributions were not made by 26 – 27 % families in Farooqi Masjid to as much as 84% in Patkar Compound. Overall, in most areas about 60 % of the families did not contribute any money at all. The contribution made was examined in relation to the families' responses about the regularity of the collector (Table 12). In almost half the pockets, 20–40 % of the families did not pay, even if they stated that the collector was regular. It appeared therefore, that the residents expected this door-to-door collection as a free service.

Table 11. Amount Paid by Families for COPRICOL

Area	n	Amount (Rs. /month)	Percent families
Patkar Compound	633	0	84.4
		2	4.3
		3	11.1
		5	0.3
Macca Masjid	369	0	60.7
		2	2.4
		3	35.6
		4	0.0
		5	0.8
Sada Bahar	50	0	66.0
		2	2.0
		3	32.0
Dhangarwadi	151	0	62.0
		2	9.0
		3	0.7
		5	23.8
		10	12.8
			0.7
Wadarwada	275	0	30.5
		1	0.4
		2	66.9
		5	1.8
		10	0.4
Janata Colony	1444	0	56.6
		2	3.8
		3	35.5
		4	2.4
		5	1.3
		10	0.3
Khandesh Mohalla	207	0	27.5
		3	72.5
Farooqi Masjid	349	0	25.8
		2	2.0
		3	71.9
		5	0.3
Juhu Galli	51	0	64.7
		2	2.0
		5	33.3
Gilbert Hill	457	0	37.0
		2	11.1
		3	60.8
		5	0.7
		10	0.4
Gamdevi Dongri	1894	0	26.1
		2	4.3
		3	65.4
		4	2.0
		5	2.1
		10	0.1

Table 12. Amount paid by Families and Regularity of Service given by Garbage Collectors

Area/Pocket	Amount Rs./Month	Regular	Irregular	Absent
Patkar Compound	0	25.0	-	84.7
	2	75.0	-	3.8
	3	-	-	11.2
	5	-	-	0.3
Macca Masjid	0	15.0	50.9	98.2
	2	3.7	5.3	0.6
	3	77.6	43.9	1.2
	5	2.2	0.00	-
Sada Bahar	0	51.4	-	100
	2	2.9	-	-
	3	45.7	-	-
Dhangarwadi	0	95.5	-	17.8
	2	-	-	1.6
	3	33.7	-	53.2
	5	1.1	-	27.4
Wadarwada	0	0	0.8	100.0
	2	1.8	-	-
	3	94.5	96.3	-
	5	2.5	2.9	-
Janata Colony	0	44.2	60.4	87.3
	2	7.2	2.7	0.9
	3	46.0	34.7	10.9
	5	3.3	1.0	0.9
Khandesh Mohalla	0	-	100.0	100.0
	3	100.0	-	-
Farooqi Masjid	0	7.5	29.7	65.6
	2	2.3	2.7	1.1
	3	90.2	67.6	33.3
Juhu Galli	0	20.0	4.3	56.5
	2	47.5	4.3	1.6
	3	32.5	91.3	41.9
Gilbert Hill	0	18.8	0	93.2
	2	2.1	0	1.4
	3	79.2	100.0	5.4
Gamdevi Dongri	0	6.6	13.1	96.3
	2	5.3	3.5	1.7
	3	77.6	79.4	2.0
	4	6.8	2.3	-
	5	3.7	1.4	-

Consolidating and Stabilizing for Sustainability and Cessation of Financial Support

Through intensive efforts by the SNDT team inclusive of the UBSP and the 2 IDRC supported projects, the slum dwellers have begun to appreciate the need for environmental sanitation in most pockets. From Year II onwards, the transfer of ownership of COPRICOL had been initiated by involving the NHCs in monitoring and supervision of garbage collectors. In year III, the NHCs were asked to certify and notify the SNDT administration on a monthly basis, for the disbursal of salaries to garbage collectors and they were authorized to disallow pay for the days that the collector's remained absent. Most NHCs, in whose areas, the COPRICOL was operating, took up this responsibility willingly.

Dialogues were also initiated about the financial sustainability and NHCs were asked to considered taking up the responsibility of money collection and direct disbursal of payments to the garbage collectors. They were also told that the money accrued from sale of compost could be kept by them to address any SWM issue, and that SNDT would continue to support the payment for the composting process for a year or two after cessation of the project. However, in some pockets (4 pockets covering approximately 1500 families) which are situated on elevated land (on the hillside), the residents still prefer to throw garbage into the open area below or adjacent open areas since this does not pose immediate problems for them. In Patkar Compound, there are about 300 homes adjoining a wall, which separates the slum from private land, which is an open field. Here too, the slum dwellers prefer to toss their garbage bags over the wall. No amount of persuasion or coercion seems to have any effect.

At the Municipal level, the issue of environmental sanitation has been brought under the aegis of the Health Post and the functionaries are authorized to impose a fine/penalty for littering.

In one of the packets (Janata Colony) one of the Health Post functionaries was beaten up by the slum residents for reprimanding one of them for littering and for attempting to impose a fine. In the same pocket, and in Gamdevi Dongri, two of the RCVs were beaten up when they went to collect the monthly dues for the COPRICOL. Further in the same pockets, the local residents have threatened the Municipal functionaries.

In year III, the Project team has faced several problems, which have made it extremely difficult to ensure sustainability of the COPRICOL.

Constraints:

The S.N.D.T. teams faced several constraints, which had considerable implications for the financial sustainability of the COPRICOL.

- Most of the slum residents wanted the COPRICOL but approximately 50% or even less were willing to pay.
- The irregularity and frequent absences of the garbage collectors was a cause for the non-payment and demotivation. In some pockets like Farooqi Masjid, which in the beginning had been the most responsive, ultimately opted out of the COPRICOL because the collectors remained absent for long periods, 1-2 months.
- The garbage collectors would frequently remain absent without prior notice and no substitute would be provided.
- Some collectors would not collect the garbage from all households.
- The collectors did not like a cut in salary for non-performance. Moreover for a task to which they did not give more than 2 – 3 hours per day, they began to expect a salary of more than Rs. 1000/- per month as well as gifts during festivals and bonus.
- This resulted in refusal of many households to pay their monthly dues. Thus, the financial sustainability of the COPRICOL after cessation of project support from IDRC was a point of major concern.
- In the Wireless Road pocket, very few of the 770 families were willing to make the financial contribution, although they all wanted the COPRICOL scheme. Similarly, in Janata Colony not even 10 % of the families pay for the collection.

By the beginning of the third year of the project, the contribution from the Wireless Road area was almost nil. Meetings were held with the NHCs and some local leaders, and it was emphasized that if not community contribution was forthcoming, it would not be possible for SNDT to continue the COPRICOL after IDRC support ceased. Inspite of this. the residents of this pocket insisted that services be given free.

- Similar circumstances were encountered in Janata Colony and in almost half of the Patkar Compound pocket.
- NHCs or other residents did not involve themselves in identifying new garbage collectors. In only 1 large pocket i.e. Gamdevi Dongri, where the IDRC-supported project on improving nutritional status was ongoing, did the Mahila Mandal women start to work on this problem with the project staff.
- Several conservancy workers of the Municipality expected very high remuneration, which could not be supported through community contribution.
- The behaviour of slum residents in some pockets was a deterrent. Garbage collectors often complained that some residents were uncooperative, used abusive language and on one occasion resorted to violence.
- Garbage collectors expected SNDT to give an assurance that they would be paid since, they did not have the confidence that the community contribution would cover their monthly salary.
- Some of the supervisors were less than honest and did not hand over the entire collection.
- Monthly contributions would trickle in and it would take supervisors almost 3 weeks to collect one month's contribution from their respective pockets. This is because in many homes, they had to pay 3-4 visits to collect the money in some they had to coerce the people to pay.
- Frequent illness and morbidity among the collectors was one reason for their absence. Analysis of the garbage sample showed a very high bacterial count (TBC > 10^{10}) and very high counts of pathogens such as *Salmonella, Shigella,* typical *Coliforms* and pathogenic fungi. Daily and prolonged exposure to these pathogens was probably responsible for the morbidity among the garbage collectors.
- The turnover of project staff was an impediment. New staff required orientation and training not only about the project and its technical aspects but also about working with the community.
- Collectors did not like their salaries being cut for their absenteeism and about half of them left abruptly without notice in the beginning of 1998.

At this juncture, it was thought worthwhile to obtain services from a voluntary organization rather than from individual collectors, since the problems were linked to the garbage collectors' erratic attendance and performance.

- Whatever inorganic material is saleable is generally segregated at household level. As the project expanded however, the project staff could not continue the door-to-door visits to all homes. Hence, the segregation of waste fell to very low levels. To overcome this problem, the garbage collectors were asked to separate the biodegradable and inorganic waste. The latter is picked up by rag pickers for sale. The Centre has experienced this problem with respect to segregation for Environment Education, Bangalore (9). It was observed that whenever the motivator goes around, personally emphasizing the need to segregate waste, the segregation levels rise, but fall again after some time.

Accordingly, an NGO Citizen's Social Organization was identified with the help of the Consultant Mr. Panjwani. Citizen's Social Organization concentrates on Solid Waste Management and mainly supplies manpower to Institutions including the Mumbai Municipal Corporation for maintenance of environmental cleanliness. The general terms and conditions of this Organization are:

(i) For each voluntary worker the organization has to be paid Rs. 1500 per month.

(ii) Each volunteer will work for a 7-hour period every day and the Institution who is paying for the services may assign any work to the worker within the 7 hour work period. Tasks can include toilet cleaning, garbage collection, cleaning of drains etc.

(iii) One worker is assigned to a population of approximately 1000 i.e. approximately 200 - 250 families.

(iv) For a group of 9 workers, one Supervisor is provided.

Dialogues were initiated with Mr. Bhandare. President of the Citizen's Social Organization (CSO) since they also supply workers on a contract basis to the Mumbai Municipal Corporation. Further, it was felt that working with an organization may ease problems of absenteeism and non-performance compared to the situation where each garbage collector had to be dealt with on an individual basis.

The dialogues were initiated in October 1997. The Organization agreed to help. However, as per their rules, they also stated that they would levy a service charge of 10% and that a minimum of 9 volunteers would have to be employed.

After studying the financial implications on a long-term basis, SNDT requested CSO to waive the service charges since SNDT did not have the confidence that the entire amount would be available from the community. once the project funding ceased. SNDT also requested CSO to absorb those of the garbage collectors participating in COPRICOL who were willing to join CSO.

CSO was also informed that dialogues would be held with the NHCs about initiating this new scheme. Payment of Rs. 1500 for a population of 1000 i.e. approximately 200 - 250 families meant that the families would have to pay at least Rs. 7 to 7.50 per month per family.

The SNDT team proposed to the slum NHCs that since the CSO voluntary workers would be in the slum for 7 hours per day, they could assign the task of cleaning gutters/drains or toilets and pay an additional amount for this as a consolidated sum.

Generally, prior to this, cleaning of gutters and drains was undertaken sporadically wherein families would each pay at least Rs. 5/- and many would pay as much as Rs. 10 or Rs. 20. In most pockets, this cleaning exercise used to be done once a month.

Hence, the SNDT team explained to the NHCs that within a sum of Rs. 7 to 8, they could get several things attended to on a more regular basis.

In some pockets, like Wireless Road and Janata Colony, residents did not want to pay and expected that they should receive the service free of cost. In these 2 pockets, many families as well as a few local leaders opined that the Municipal Corporation was giving free door-to-door service but SNDT wanted to indulge in profiteering by exploiting the slum dwellers.

In one of the pockets, the slum residents wanted to bargain and stated they would give only Rs. 1000 per month.

In one or two pockets, they wanted only garbage collection done and in one pocket they preferred toilet cleaning and maintenance to cleaning of gutter and drains.

Thus, the requirements of each pocket vis-a-vis the money that would possibly be accrued was examined by the community organizers with their respective NHCs on individual basis.

CSO informed SNDT in March '98 that, it did not want to liaise directly with each NHC for the financial aspects and that it would work only with SNDT directly such that SNDT would require to be the link between the slum and CSO. The work was actually started by CSO in mid-June 1998.

However, the problem or irregular attendance, and poor coverage continued. Further, it was observed that CSO was not able to supervise or control the problems. To some extent this was because the workers felt that they were paid too little for a day's (5 hours per day) work. Eventually in October 1998, one of the workers from CSO volunteered to bring in more workers, if they could work independently. Since SNDT was in the process of withdrawing from the project activities, the men were asked to work in those pockets where NHCs could pay them adequately and the NHCs were asked to assume the responsibility for supervision and payment of salary to the collectors. The NHCs in Dhangarwadi have taken up this task and there is no financial liability for SNDT. The monthly collection in this pocket is approximately Rs. 1800 for two collectors. In Gamdevi Dongri the registered women's group is gradually taking over from SNDT. In Patkar Compound, Macca Masjid and Farooqi Masjid, the NHCs have just resumed the COPRICOL and are willing to deal directly with the collectors. In Wireless Road and Janata Colony, an absolute refusal to pay and the behaviour of many of the residents viz. Abusing the project staff and collectors as well as beating of the RCVs led to the decision that the COPRICOL could not continue in these pockets free of cost. The financial burden for these two pockets alone covering almost 2500 families would be Rs. 60,000 per year. The NHCs and local leaders in these pockets also did not show any interest in composting to reduce waste.

Thus at the end of the project, from the 10,000 families originally covered, approximately 7500 - 7600 families still participated in the solid waste management in January 1999 when project funding ceased.

However, in most pockets the people were more conscious about the need to keep their areas clean and the slum is cleaner than it used to be prior to the project.

Evaluation before Withdrawal:

Towards the end of the project in April 98, a survey was undertaken to assess the existing practices and opinions of the slum dwellers. A total of 679 families were surveyed. These families were included by systematic random sampling, to cover approximately 10 % of the population in the pockets where COPRICOL was operational. The practices of the slum dwellers were as follows:

Receptacle used to store garbage

Plastic container	47.9 %
Plastic bag	45.9 %
Tin container	3.2 %
Others	1.7 %
None	1.3 %

Less than half the residents used the container distributed as part of the COPRICOL. It appears therefore, that distribution of containers need not be included, as part of a primary collection system since the cost of each plastic container was approximately Rs. 15.

Housewives were asked whether they separate organic and inorganic/dry waste. Most women (83.2 %) did not. However, percentage separating at end of the project was 16.8%, compared to pre-project figure of 14.2 %.

Substances separated were:

Food/Vegetable/Fruit waste	59.6 %
Plastic	46.1 %
Paper	12.4 %

Separated materials such as tin and glass were sold by 22.5 % of the families. However, the separation of organic and inorganic waste by the 16 % of families was not regular since the residents could not perceive its importance. Only 25.8 % families separated the waste daily, whereas for the rest of the families, the observations were:

Separate once in 2-3 days	26.9 %
Once a week	30.3 %
Occasionally	16.9 %

Knowledge about COPRICOL:

Who takes responsibility for garbage collection:

Garbage collector/RCVs/NHC	72.9 %
No one	22.9 %
Do not know	3.2 %
Municipal Corporation	1.1 %

More than two-third of families knew about the COPRICOL:

Almost 30 % residents stated that 2 persons collected the garbage whereas 53.7 % said one collector comes to collect the solid waste. Residents were asked whether they used the communal facility. Almost two-thirds i.e. 63.9 % used the facility compared to 58.9% who used it prior to the project.

Payment for COPRICOL

Almost three-fourth (70.2 %) families stated they paid Rs. 3 per month for the COPRICOL. The remaining 29.8 % did not pay because the garbage collectors do not come to their homes.

Opinion about Scheme

Only 8.5 % of the residents stated that the system was unsatisfactory because the collector is not regular.

Opinion about cleanliness in the Pocket

A greater proportion (59.2 %) felt that their area/pocket as well as the whole slum is clean. They were asked how they keep their immediate surroundings clean:

Responses were:

Wash with water and soap	27.4 %
Sweep	65.8 %
Do nothing	5.8 %

Interest and Participation in COPRICOL

About two-thirds (63.1 %) were interested in collectively taking up responsibility. Participation in COPRICOL was in different ways:

Will pay collector but not take responsibility	57.9 %
Participate in submitting requests/ signature campaigns	49.9 %
Attend meetings	45.0 %
Go to BMC	43.8 %
Monitor the COPRICOL	49.1

Almost half of the families in the pockets therefore were involved in the COPRICOL implementation and almost all of them knew about it.

Thus it appears that awareness about the need for environmental sanitation was been definitely enhanced through the project. However, since all slum dwellers do not pay their monthly contributions, the financial sustainability of COPRICOL is not assured. Further, most of the garbage collectors are casual workers and it is difficult to find a substitute in case they remain absent. Irregularity on their part is an important determinant of whether the slum families pay the monthly contributions and there is no means by which any disciplinary action or measures can be taken.

State of garbage disposal at initiation of project

Roads tend to be cleaner with COPRICOL (1998-99)

State of Masonry bins at initiation of project

Masonry bins constructed through the project

COPRICOL – WRR

One of the primary objectives of the project was waste reduction by recycling in conjunction with the COPRICOL viz. the community-based primary collection system. It was envisaged that waste reduction would be achieved by (a) small scale composting in situ and (b) enhancement of trading of inorganic materials for recycling.

Several methods are available for solid waste disposal (10):

- Sanitary land fill
- Incineration
- Anaerobic digestion/bio-gas generation
- Composting
- Neutralysis/Fuel Pelletisation

Land-fill disposal

- The disposal of domestic solid waste in a well-managed land adopting scientific methods of operation is termed as 'Sanitary land-fill'. During the 1950s and 1960s, it was called 'Controlled tipping'. The process for the disposal of household or organic waste by controlled tipping has been accepted since the early 1930s.
- The most important and crucial aspect relating to landfill is identification of a suitable site. All landfill sites should satisfy the criterion that there would be a resulting benefit to the community.
- Land-fill programmme is a very time consuming process and careful operations are needed throughout the period. The method can be practiced where large area of land is available or land is to be reclaimed which otherwise is likely to be abandoned after carrying out specific operations.

Anaerobic digestion/bio-gas & power generation

Anaerobic digestion is the process most frequently used for biological decomposition of organic wastes, both domestic and industrial, loaded with high concentration of organic matter in the absence of oxygen. In the process, the organic wastes are hydrolyzed, liquefied and converted to methane, carbon dioxide and residual indigestion matter. As a result, a well-mineralized residue is obtained. The gases liberated are used for fuel and lighting. The mineralized residue can be used as manure. There is an appreciable saving in recurring costs because of the utilization of this biogas.

Indian garbage can be effectively digested only after proper blending with several treatment plant sludges, in order to adjust the carbon-nitrogen ratio as the cost of the compost production is several times higher than conventional manure used by farmers.

Fuel Pelletisation

Fuel pellets are small cubes/cylindrical pieces made out of garbage. The calorific value of the product is quite close to the coal and therefore, it can be a good substitute for coal, wood etc. The cost efficient fuel pellets, apart from replacing coal, can also replace petroleum products for both domestic and industrial use.

Department of Science and Technology in Mumbai (Deonar) have set up a pilot plant for processing garbage into fuel pellets. It is based on indigenous technology. A similar project has been established by M/s. Shivshankar Engineering Company Pvt. Ltd., in Bangalore and has got regular production of fuel pellets compacting 50 tonnes of garbage per day converting into 5 tonnes of fuel pellets. The fuel pellets can be designed both for the industrial and domestic uses. A stove that facilitated effective combustion for domestic purposes has also been developed.

Incineration/pyrolysis of solid waste

Incineration is used mainly as a means of achieving maximum volume reduction of municipal wastes. It is usually a costly method of disposal than controlled tipping. The processes of incineration are favoured as a method of disposal when there is shortage of tipping facilities. Incinerators at initial stages were of the multi-cell batch type. Facilities are provided within the plant to screen out surplus fines, and to salvage ferrous metals. These installations are labour intensive and to solve these problems, incinerators with continuously moving grates came into operation.

To produce best possible design of an incinerator, it is important to know as much as possible about the quantity and quality of the refuse to be handled. The basic design parameter of a municipal refuse incinerator is the "maximum furnace heat release". This is desired by combining the maximum calorific value of the refuse with the specified incineration rate of refuse having that maximum calorific value.

In recent years much research has been undertaken into incineration of refuse under oxygen-deficient conditions, and this process is called 'Pyrolysis'. The objective of pyrolysis of refuse has generally been to produce a gas which could be stored and used when advantageous, whereas it is not practicable to store the energy recovered from normal incineration of refuse. Other possible advantages of treating the wastes by pyrolysis include a reduced volume of waste gases to be handled in the gas cleaning plant, fans and chimney, with consequent lower cost of these items, and the discharge of clinker as a dense granular material.

A major disadvantage of pyrolysis is that designs developed so far have not been able to take in crude refuse as do large incinerators and the cost of producing a prepared material suitable for pyrolysis is considerable.

Composting:

This is probably the oldest form of waste disposal. Solid organic waste is degraded microbially in a moist, warm, aerobic environment. It is considered as a means of accelerating the process of converting organic waste into a product of significant value. Vermiculture has also been used to convert organic matter into biofertiliser.

The latter 3 methods are possible, feasible solutions due to the following (10):

- Approximately three-fourths at least of waste components can be reused/recycled to derive value-added products, which can have sustainable demand.
- Conversion into compost can provide complementary products to improve usage efficiency of chemical fertilizer.
- Can prevent land deterioration
- Can reduce the effect of polluting substances and the toxicant effects in the soil.
- Can reduce dumpsite land requirements and waste management expenses incurred by Municipal Corporations.
- May help in revenue generation for municipal corporations from land lease rent and through sales of the product.

However each of these options has its merits and demerits which are summarized herein:

Various Waste Disposal Methods and their Merits/Demerits

Method of Disposal	Demerits	Merits
Land Filling	• Restricted site availability cannot last longer • Contaminates water sources • Anaerobic gas production explosions	• Easy operation • Land gets levelled
Open Land Dumping	• Environment pollution • Costly large area occupied • Increasing maintenance cost of open dumps • Ugly look to the cities and surroundings • Smoke and fire • Shifting of locations due to space becoming full	• Lower initial costs • Easy for rag pickers • Non-skilled job
Burning/ Incineration	• Smoke and gaseous contamination of environment • Temperature rise • Diesel costs higher • Capacity for incineration is a constraint	• Incineration is a standard hygienic operation • Burning is easy operation
Bio-conversion into organic manure	• Technological constraints • Higher capital costs • Requires Govt. support production • Value addition to waste resource • Sustainable approach	• Highly useful product for land improvement crop

Source: Reference 10

In the present project, before deciding upon the method of waste disposal, it was necessary to determine the amount of waste generated in this slum and its composition, whether it would lend it self better to one of the three methods.

Solid Waste: Quantity, Physical and Chemical Composition

The solid waste generated in a community is highly dependent on various factors such as economic status, environmental legislation, technological advances etc. Typical municipal solid waste would include food waste, paper, textiles, leather, rubber, wood, plastics, iron, aluminum, other metals, glass, garden waste, rags, organic, ash, dust/debris etc. The heterogeneous nature of solid waste is also subject to change based on temporal and seasonal variations.

The amount of solid waste generated should be known if the problem of solid waste disposal has to be tackled. Hence, before setting up the COPRICOL-WRR the amount and type of waste generated in the slum was estimated. The amount of refuse collected from urban areas in India has been estimated to be 0.3 to 0.5 kg per person per day. In Mumbai City, the 10 million people were estimated to generate approximately 0.4 kg/person/day.

In the present project, the amount of solid waste generated per household was weighed in 10 % of the families for 7 consecutive days. The weighment was carried out in 8 pockets of the slum; on a total of 350 families (Table 13).

Table 13. Garbage collected per Day per House (kg)

Area	Patkar Compound	*Aman Welfare Society	*Ajmeri Mohalla	*Noor Masjid	*Saibaba Colony	Janta Colony (8/11/97–15/11/97)	Janta Colony (20/10/97–27/10/97)
No. of Houses	**75**	**24**	**18**	**12**	**25**	**95**	**75**
Day 1	1.01	0.72	0.72	0.85	0.55	0.98	0.73
Day 2	0.96	0.67	0.79	0.91	0.73	1.01	0.74
Day 3	0.99	0.67	0.83	0.90	0.77	1.01	0.72
Day 4	1.07	0.70	0.84	1.06	-	0.96	0.80
Day 5	0.96	0.67	0.97	0.98	-	0.90	0.88
Day 6	1.05	0.69	0.89	0.97	-	0.91	0.82
Day 7	0.95	-	0.88	0.83	-	0.92	0.82
Average	**0.99**	**0.69**	**0.85**	**0.93**	**0.68**	**0.96**	**0.78**

Individual pockets in Gamdevi Dongri

The amount of solid waste per family ranged from 0.6 kg/day to approximately 1 kg/day. The mean values for the 8 pockets is presented in Table. The overall mean garbage per household was 0.88 ± 0.27 kg per day, ranging from 0.67 kg/day per household to 0.996 kg/day/household.

The slum houses approximately 10,000 to 12,000 families. Hence, the total amount of solid waste generated in the slum from households alone would range from approximately 8,800 to 10,560 kg on a daily basis.

NEERI observation (11) indicated that the per capita waste, reaching disposal site was 0.5 kg per capita/day in Mumbai and Calcutta. In 3 cities of Andhra Pradesh the per capita values were approximately similar 0.17-0.2 kg/capita/day.

The per capita waste generated in the present study was 0.13 kg to 0.199 kg assuming the average family consisted of 5 members. This estimate represented the waste collected in the morning. It is possible that in many families an additional amount of organic with some inorganic waste would be generated through food preparation at various meal times etc.

In addition, to household garbage, wastes generated from shops were estimated in 3 pockets out of 10 selected by random sampling. The total number of shops studied was 80. Solid waste produced/generated by all shops in the pocket were studied for 7 consecutive days and included small grocery stores, flour mills and furniture shops. The proportion of grocery stores was the highest (71 %) and furniture shops the least (13.2 %). The amount of solid waste generated by these shops is presented in Table 14.

Table 14. Solid Waste generated in shops

Type of Shop	Mean ± SD (kg/shop)	Range (kg)
Furniture manufacture	6.90 ± 2.01	4.27 – 9.77
Flour Mills (Wheat grinding)	4.51 ± 1.29	2.64 – 6.21
Grocery Stores	2.92 ± 0.69	1.39 – 4.81

The shop owners were asked what they did with the solid waste. The grocery shops solid waste is mainly paper and plastic. In case of furniture shops, it is sawdust. Grocery shop owners keep the plastic for rag pickers who sell it. Paper is thrown in the garbage. These shop owners including the furniture shops, flour mills, as well as some vegetable vendors have been persuaded to hand over the solid waste to the COPRICOL collectors for composting.

Quality/Composition of Solid Waste

Study of quality of solid wastes requires attention to be paid to the physical and chemical composition. This information helps to decide whether the waste is putrescible or not, combustible or non-combustible, recyclable or non-recoverable, thereby helping to decide upon the method of disposal that could be adopted. The moisture content of the solid waste gives an idea of the combustibility of the material. Other component which are estimated include:

- Proximate analysis which includes moisture, volatile matter, ash, fixed carbon
- Fusion point of ash.
- Ultimate analysis, C, H, O, N, S and ash percentage.
- Heating value i.e. calorific value
- pH, organic matter content, phosphorus, the C/N ratio.

This information helps to evaluate alternative equipment needs, system programmes/ plans especially for a long-term efficient solid waste management programme. In the present project, physical and chemical analysis of solid waste was carried out.

Physical Analysis of Solid Waste:

Assessment of physical characteristics of the refuse indicates the amount of compostable, non-compostable, recyclable, fine earth and ash.

Analysis was carried out for 10 consecutive days, once in each season: Monsoon, Winter and Summer. Physical analysis was carried out for each trolley that carried the solid waste collected through the COPRICOL at each communal waste disposal facility. The only day analysis was not carried out was on Sundays when the collectors had their weekly holiday.

At least one major collection point in each of the large pockets was included. A total of major 7 collection points were selected to obtain a representative for the entire slum. The number of trolleys varied according to the proximity of the communal collection facility to the slum pocket. Thus the highest numbers of trolleys collect and transport solid waste to 3 locations in Patkar Compound, Farooqi Masjid and Parivar Society.

In the monsoon, a total of 167 trolleys at 4 collection points analyzed, the average number being approximately 4 per collection point per day. In the winter, 254 trolleys at 4 collection points were analyzed, the average being 6 trolleys per collection point per day. In the summer, the analysis was carried out at 3-collection point, the average being 5-6 per point per day. The total numbers of samples analyzed were 501. The protocol for analysis is described is Appendix III.

The samples were analyzed for paper, plastic, glass & ceramics, wood biodegradable matter, coconut, rubber & leather, textile, bones, ash & fine earth, and fine organic matter. The observations by site and season are summarized in Tables 15, 16, 17.

Table 15. COMPOSITION OF SOLID WASTE

Physical Analysis: Summer

Area		Paper	Plastic	Glass & ceramics	Metal	Bio-degradable	Wood	Coconut	Rubber & leather	Textile	Bones	Bricks & Stones	Coal	Ash & fine earth	Fine organic matter	Total organic matter
Bhavans	Mean	8.74	7.69	3.07	3.44	34.36	3.12	4.53	9.56	7.12	-	0.17	-	-	18.2	60.21
	SD	0.92	0.76	1.61	1.39	1.62	1.47	1.45	2.13	2.28	-	0.18	-	-	2.63	3.07
	CV	0.10	0.11	0.6	0.46	0.05	0.5	0.36	0.25	0.38	-	0.11	-	-	0.14	0.05
Farooqi Masjid	Mean	8.33	7.33	0.02	2.38	29.69	3.39	4.90	5.78	4.98	3.10	5.17	-	-	24.20	62.18
	SD	0.92	1.31	0.03	1.14	4.77	1.59	1.47	2.37	1.54	1.25	2.23	-	-	5.56	2.59
	CV	0.12	0.18	0.13	0.63	0.17	0.63	0.34	0.56	0.31	0.4	0.5	-	-	0.23	0.04
Macca Masjid	Mean	7.94	7.96	2.06	3.94	34.05	2.48	5.12	11.73	9.53	-	0.17	-	0.15	15.51	62.38
	SD	2.27	2.06	2.29	2.71	5.25	2.03	3.21	3.57	3.87	-	0.25	-	0.21	2.48	5.31
	CV	0.31	0.26	0.89	0.8	0.16	0.78	0.73	0.32	0.49	-	1.41	-	0.14	0.16	0.11
Average	Mean	8.34	7.66	1.72	3.25	32.7	3.0	4.85	9.02	7.21	1.03	1.84	-	0.05	19.3	61.59
	SD	1.37	1.38	1.31	1.75	3.88	1.7	2.04	2.69	2.56	0.42	0.89	-	0.07	3.56	3.66
	CV	0.18	0.18	0.54	0.63	0.13	0.64	0.48	0.38	0.39	0.13	0.67	-	0.05	0.18	0.07

SD = Standard Deviation, CV = Coefficient of Variation

All values are calculated on wet weight basis and are given in percentage

Table 16. **COMPOSITION OF SOLID WASTE**

Physical Analysis: Winter

Area		Paper	Plastic	Glass & ceramics	Metal	Bio-degradable	Wood	Coconut	Rubber & leather	Textile	Bones	Bricks & Stones	Coal	Ash & fine earth	Fine organic matter	Total organic matter
Bhavans	Mean	8.92	7.54	0.13	2.09	34.57	3.07	3.47	6.76	5.47	2.69	5.7	-	-	18.74	60.54
	SD	0.82	0.09	0.08	0.11	0.26	0.14	0.15	0.17	0.12	0.10	0.21	-	-	0.25	2.66
	CV	0.10	0.01	0.06	0.05	0.01	0.05	0.03	0.03	0.03	0.04	0.04	-	-	0.01	0.04
Patkar Compound	Mean	8.73	8.21	1.25	3.50	34.92	2.77	1.71	9.36	9.67	-	4.11	-	-	15.78	55.96
	SD	1.66	2.14	1.49	3.25	5.82	1.99	1.36	4.01	3.79	-	2.94	-	-	3.07	5.95
	CV	0.20	0.26	1.18	1.03	0.17	0.78	0.82	0.39	0.41	-	0.72	-	-	0.20	0.11
Macca Masjid	Mean	8.93	7.59	1.0	3.12	39.17	2.17	1.42	10.30	6.89	1.09	1.07	0.16	0.76	16.35	65.13
	SD	0.14	0.11	0.09	0.26	3.52	1.68	1.20	3.19	3.34	1.27	1.05	0.36	0.94	3.34	4.68
	CV	0.02	0.02	0.08	0.08	0.09	0.82	0.93	0.32	0.51	1.26	0.74	0.45	1.37	0.21	0.08
Parivar Society	Mean	9.51	8.88	0.44	1.10	35.40	3.63	5.76	5.38	5.79	1.90	5.27	-	0.16	16.76	55.51
	SD	0.06	0.05	0.04	0.08	0.30	0.13	0.16	0.20	0.12	0.06	0.19	-	0.03	0.25	2.31
	CV	0.01	0.01	0.06	0.10	0.01	0.03	0.03	0.04	0.02	0.06	0.04	-	0.09	0.02	0.04
Average	Mean	9.02	8.05	0.71	2.45	36.02	2.91	3.09	7.95	6.96	1.42	4.04	0.04	0.23	16.9	59.23
	SD	0.67	0.60	0.43	0.95	2.48	0.99	0.72	1.89	1.84	0.36	1.10	0.09	0.24	1.73	3.90
	CV	0.08	0.30	0.35	0.06	0.07	0.07	0.45	0.20	0.24	0.34	0.39	0.11	0.37	0.11	0.07

SD = Standard Deviation, CV = Coefficient of Variation

All values are calculated on wet weight basis and are given in percentage

Table 17. COMPOSITION OF SOLID WASTE

Physical Analysis : Monsoon

Area		Paper	Plastic	Glass & ceramics	Metal	Bio-degradable	Wood	Coconut	Rubber & leather	Textile	Bones	Bricks & Stones	Coal	Ash & fine earth	Fine organic matter	Total organic matter
Tilak Dham	Mean	10.43	8.29	3.5	1.95	35.26	4.49	3.76	5.07	5.48	0.2	5.67	-	1.84	13.76	51.70
	SD	1.13	0.82	1.5	1.19	2.77	2.66	1.62	2.58	2.29	0.22	2.2	-	0.97	2.24	3.43
	CV	0.11	0.10	0.48	0.72	0.08	0.55	0.53	0.42	0.43	0.45	0.47	-	0.51	0.16	0.06
Community Centre	Mean	9.41	8.56	3.37	0.81	35.76	4.98	4.61	6.07	4.52	0.47	6.85	-	0.97	13.63	62.13
	SD	1.03	1.0	1.89	0.71	2.65	1.38	1.65	1.59	1.61	0.29	1.93	-	1.07	1.91	3.29
	CV	0.11	0.12	0.57	1.33	0.08	0.29	0.37	0.28	0.43	0.71	0.28	-	0.86	0.15	0.06
Farooqi Masjid	Mean	8.89	7.86	3.65	0.59	36.2	4.78	5.83	6.55	4.04	1.32	5.15	-	0.09	14.99	61.81
	SD	0.99	0.96	0.11	0.73	2.98	1.37	2.75	1.78	1.48	1.02	1.84	-	0.17	2.15	3.43
	CV	0.13	0.13	0.48	1.35	0.08	0.34	0.45	0.27	0.40	0.75	0.38	-	0.6	0.14	0.06
Patkar Compound & Macca Masjid	Mean	10.00	8.85	3.42	1.19	36.43	4.88	4.6	5.06	5.01	0.51	4.94	-	1.36	13.75	59.73
	SD	1.25	1.17	1.55	1.0	3.33	2.64	1.66	2.02	2.10	0.45	1.93	-	1.69	1.89	3.52
	CV	0.14	0.12	0.42	0.58	0.09	0.52	0.39	0.66	0.41	0.93	0.44	-	0.82	0.16	0.06
Average	Mean	9.68	8.39	3.49	1.14	35.91	4.78	4.7	5.69	4.76	0.63	5.65	-	1.07	14.03	58.84
	SD	1.1	0.99	1.26	0.91	2.93	2.01	1.92	1.99	1.87	0.5	1.98	-	0.98	2.05	3.42
	CV	0.12	0.12	0.49	1.0	0.08	0.43	0.44	0.41	0.42	0.71	0.39	-	0.7	0.15	0.06

SD = Standard Deviation, CV = Coefficient of Variation

All values are calculated on wet weight basis and are given in percentage

The total organic matter did not appear to vary by season and the biodegradable matter was approximately 33 to 36 %. These observations were compared to values reported in the literature (Table 18).

Table 18. Comparison of Physical Characteristics of Refuse from some Cities in India (values are in % by wet weight).

	Paper	Plastics	Metals	Glass	Ash & fine earth	Total compostible matter
Calcutta	3.18	0.65	0.66	0.38	34.0	47.0
Delhi	6.29	0.85	1.21	0.57	36.0	35.0
Madras	7.85	0.88	0.95	0.96	28.0	48.0
Hyderabad	4.81	0.83	1.22	0.93	36.0	37.0
Ahmedabad	3.02	0.84	0.42	0.23	34.0	49.0
Kanpur	2.97	0.62	0.45	0.37	46.0	41.0
Jaipur	3.02	0.80	0.64	0.39	50.0	26.0
Jabalpur	2.02	0.69	0.38	0.35	43.0	40.0
Chandigarh	6.17	0.33	0.22	0.20	39.0	35.0
Sangli	3.04	0.35	0.20	0.36	41.0	50.0
Present	8.34	7.66	1.14	0.71	0.05	58.84
study	9.68	8.39	3.25	3.49	-1.07	61.59

1 Data for 1971-73
2 Includes glass and ceramics

The percentage of paper and plastics was much higher in the Gilbert Hill samples and the total compostible matter slightly higher compared to the observations made by NEERI in 1971-73 (11).

The contents of paper, plastics and glass are reported to increase with increase in population. The amount of paper observed in the present study was much lower than the developed countries but comparable to other countries. However, the percentage of plastic was almost 3 to 4 times higher than that reported for developed countries (Table 19).

Table 19. Comparison of Paper, Plastics and Total Compostible Matter

	Paper	Plastics	Total Compostible Matter
Present Study	8.3-9.7	7.7-8.4	58.8-61.6
Municipal Waste (Mumbai)	6.2-10.9	4.2-5.5	0.00
Other developing countries	2-7.5	2.0-6.0	15.0-50.0
West Germany	20-35	2.0-3.0	10.0-20.0
USA	40-55	2.0-3.0	10.0-15.0

The recyclable constituents were comparable with those reported for the city of Mumbai and its suburbs, although the plastic content was slightly higher (Table 20).

Table 20. Comparison of Results of Present Study with Municipal Data for Mumbai City

	High Income		Middle Income		Low Income		Present study
	Sept.	Jan.	Sept.	Jan.	Sept.	Jan.	
Paper	2	4	4	4	12	5	8.3-9.6
Glass	0	6	1	-	-	-	0.7-3.5
Metal	0	1	2	-	1	-	1.1-3.3
Plastics	0	2	1	1	3	1	7.7-8.4
Wood	0	2	-	-	3	1	2.9-4.8
Leather, Rubber	-	-	-	-	-	-	5.7-9.0
Textiles	2	5	-	10	4	-	4.8-7.2
Fine earth	3	2	16	6	10	14	0.01-1.1
Stone, bricks	2	-	10	-	-	9	1.8-5.7
Leaves, Fruit, Hay	55	51	45	49	38	14	32.7-36.0
Coconuts	1	9	9	10	7	1	3.1-4.9
Fine organic	35	18	13	19	20	27	14.0-19.3

Source: Reference 12

Reports on the variation in some major constituents of municipal solid waste over a decade indicate that the amount of plastic, glass and crockery has increased between 1984 and 1993 (Table 21).

Table 21. Variation in some major Constituents of Municipal Solid Waste in Greater Bombay during 1984 and 1993

ZONE	Biodegradable		Paper		Plastic		Glass & Crockery	
	1984	1993	1984	1993	1984	1993	1984	1993
City	35.58	40.56	6.38	6.32	2.78	4.62	0.63	1.48
Eastern Suburb	57.03	40.73	5.04	7.35	1.88	3.21	0.46	0.95
Western Suburb	54.62	45.54	5.07	4.53	2.24	4.46	1.09	3.64

All values are presented as wet weight

The higher amount of plastic may be attributed to increasing use of plastics in day-to-day living. Dokhale (12) noted a rise the level of combustibles from 60 to 75 % due to rise in paper, plastic etc. going into the waste collection bins in this city, rather than being recycled by rag pickers. However, this author noted a much lower amount of plastics compared to the present study (Table 20).

Chemical Composition of Solid Waste:

The moisture content gives an idea on the combustibility of material and this information would help to determine the amount of fuel that would help to determine the amount of fuel that would be required for incineration of the solid waste. The chemical composition of the solid waste is important in evaluating alternative processing and energy recovery options e.g. for use as fuel.

In the present study, the following parameters were studied.

❖ Moisture ❖ pH ❖ Conductivity ❖ Loss on ignition ❖ Organic carbon	❖ Total nitrogen ❖ Phosphorus as P_2O_5 ❖ Potassium as K_2O ❖ C/N ratio ❖ Calorific value–high and low calorific value respectively

Chemical analysis was done on the same samples included for physical analysis. The methods used for chemical analysis are described in Appendix III. The results are presented by season in Tables 22, 23, 24.

Table 22. COMPOSITION OF SOLID WASTE

Chemical Analysis : Summer

Area		Moisture (%)	pH	Conductivity ms/cm	Loss on Ignition (%)	Organic Carbon (C) (%)	Total Nitrogen (N) (%)	Phosphorus as P_2O_5 (%)	Potassium as K_2O (%)	C/N Ratio	Calorific Value HCV kcal/kg	LCV kcal/kg
Bhavans	Mean	26.14	7.01	3.11	43.85	25.44	1.16	0.49	0.49	21.99	2472.09	1670.14
	SD	0.53	0.11	0.21	1.06	0.61	0.07	0.01	0.03	1.18	57.86	58.02
	CV	0.02	0.02	0.07	0.02	0.02	0.06	0.03	0.06	0.05	0.02	0.03
Farooqi Masjid	Mean	25.36	6.8	3.07	40.51	23.5	0.96	0.51	0.51	24.67	2201.16	1491.48
	SD	0.69	0.68	0.22	1.31	0.76	0.09	0.04	0.05	2.12	58.16	52.94
	CV	0.03	0.1	0.07	0.03	0.03	0.09	0.08	0.1	0.09	0.03	0.04
Macca Masjid	Mean	25.36	7.08	3.25	46.46	26.95	1.21	0.47	0.48	22.28	2661.90	1836.67
	SD	1.31	0.07	0.3	3.26	1.89	0.03	0.05	0.05	2.18	178.99	162.75
	CV	0.05	0.01	0.09	0.07	0.07	0.03	0.12	0.1	0.1	0.07	0.09
Average	Mean	25.62	6.96	3.14	43.61	25.3	1.11	0.49	0.49	22.98	2445.05	1666.09
	SD	0.84	0.29	0.24	1.88	1.09	0.06	0.03	0.04	1.83	98.34	91.24
	CV	0.10	0.04	0.08	0.04	0.04	0.06	0.08	0.09	0.08	0.04	0.05

HCV = High Calorific Value, LCV = Low Calorific Value SD = Standard Deviation, CV = Coefficient of Variation

All values are calculated on dry weight basis except moisture & LCV which are on wet weight basis.

Due to the presence of soil and sand particles in the fine organic matter, the Loss on Ignition is varying.

Table 23. COMPOSITION OF SOLID WASTE

Chemical Analysis : Winter

Area		Moisture (%)	pH	Conductivity ms/cm	Loss on Ignition (%)	Organic Carbon (C) (%)	Total Nitrogen (N) (%)	Phosphorus as P_2O_5 (%)	Potassium as K_2O (%)	C/N Ratio	Calorific Value HCV kcal/kg	LCV kcal/kg
Bhavans	Mean	33.5	7.48	3.28	34.89	20.24	1.04	0.37	0.63	19.63	2289.32	1322.23
	SD	0.7	0.22	0.17	4.96	2.87	0.12	0.02	0.09	3.23	43.28	35.19
	CV	0.02	0.03	0.05	0.14	0.14	0.11	0.06	0.14	0.16	0.02	0.03
Patkar Compound	Mean	30.46	6.64	3.03	39.24	22.76	1.05	0.36	0.51	21.79	2507.47	1563.66
	SD	2.39	0.42	0.23	0.2	0.12	0.02	0.02	0.02	0.43	82.18	131.36
	CV	0.08	0.06	0.08	0.01	0.01	0.01	0.04	0.03	0.02	0.03	0.08
Macca Masjid	Mean	32.1	5.95	2.48	37.08	21.51	1.16	0.38	0.56	18.6	2397.65	1434.89
	SD	3.03	0.58	0.43	1.27	0.74	0.07	0.01	0.04	1.68	96.13	79.53
	CV	0.09	0.1	0.17	0.03	0.03	0.06	0.03	0.07	0.09	0.04	0.06
Parivar Society	Mean	28.63	7.07	3.19	39.13	22.7	1.09	0.37	0.60	21.28	2434.63	1567.66
	SD	2.82	0.18	0.17	0.79	0.46	0.16	0.01	0.03	3.24	59.48	117.42
	CV	0.1	0.03	0.05	0.02	0.02	0.15	0.04	0.05	0.15	0.02	0.07
Average	Mean	31.17	6.79	3.0	37.59	21.8	1.09	0.37	0.58	20.33	2392.95	1459.03
	SD	2.24	0.35	0.25	1.81	1.05	0.09	0.02	0.05	2.15	70.27	90.88
	CV	0.07	0.06	0.09	0.05	0.05	0.08	0.04	0.07	0.11	0.03	0.06

HCV = High Calorific Value, LCV = Low Calorific Value SD = Standard Deviation, CV = Coefficient of Variation

All values are calculated on dry weight basis except moisture & LCV which are on wet weight basis.

Due to the presence of soil and sand particles in the fine organic matter, the Loss on Ignition is varying.

The pH value of Macca Masjid is slightly acidic because it was slightly decomposed before the drying process.

Table 24. COMPOSITION OF SOLID WASTE

Chemical Analysis : Monsoon

Area		Moisture (%)	pH	Conductivity ms/cm	Loss on Ignition (%)	Organic Carbon (C) (%)	Total Nitrogen (N) (%)	Phosphorus as P_2O_5 (%)	Potassiumas K_2O (%)	C/N Ratio	Calorific Value HCV kcal/kg	LCV kcal/kg
Tilak Dham	Mean	40.23	6.11	2.56	39.45	22.99	0.84	0.41	0.47	29.97	2275.65	1126.76
	SD	3.34	0.4	0.4	3.27	1.81	0.19	0.03	0.04	6.12	199.12	191.32
	CV	0.08	0.07	0.14	0.08	0.08	0.2	0.08	0.08	0.22	0.09	0.16
Community Centre	Mean	39.85	7.02	2.98	42.51	24.66	0.93	0.46	0.5	27.25	2325.62	1161.45
	SD	2.25	0.18	0.58	2.35	1.37	0.1	0.05	0.05	2.98	118.44	103.75
	CV	0.06	0.03	0.2	0.06	0.06	0.11	0.1	0.1	0.11	0.05	0.09
Farooqi Masjid	Mean	41.65	6.88	2.9	41.31	23.96	0.95	0.47	0.51	25.63	2342.93	1120.41
	SD	2.39	0.38	0.54	2.91	1.69	0.12	0.05	0.05	3.78	150.99	132.8
	CV	0.06	0.06	0.19	0.07	0.07	0.12	0.11	0.09	0.15	0.07	0.12
Patkar Compound & Macca Masjid	Mean	42.87	7.05	2.5	40.86	23.7	0.86	0.39	0.49	28.16	2445.43	1155.24
	SD	2.42	0.18	0.45	2.61	1.51	0.12	0.05	0.06	3.58	155.98	143.21
	CV	0.06	0.03	0.18	0.06	0.06	0.14	0.13	0.12	0.12	0.07	0.13
Average	Mean	41.15	6.77	2.74	41.03	23.83	0.9	0.43	0.49	27.75	2347.41	1140.97
	SD	2.6	0.29	0.49	2.79	1.6	0.13	0.05	0.05	4.12	156.13	142.77
	CV	0.07	0.05	0.18	0.07	0.07	0.14	0.11	0.1	0.15	0.07	0.13

HCV = High Calorific Value, LCV = Low Calorific Value SD = Standard Deviation, CV = Coefficient of Variation

All values are calculated on dry weight basis except moisture & LCV which are on wet weight basis.

Due to the presence of soil and sand particles in the fine organic matter, the Loss on Ignition is varying.

The moisture percentage was highest in monsoon and was lower in summer. However, there was not much variation in pH or the other constituents. HCV and LCV were lower in monsoon compared to the summer. Data on 33 Indian Cities (11) shows that the calorific value of solid waste tends to increase with an increase in population. In developed countries, the C/N ratio is high, almost twice the value observed by NEERI as well as the value in the present study (Table 25).

Table 25. Comparison of Chemical Analysis in Present Study with Reports in Literature

	NEERI Data	USA	West Germany	Present Study
Moisture Content	22-31	20-30	-	25-41
C%	12-15	25-30	-	21-25
N%	0.6	0.6	0.1	0.9-1.1
Pas P_2O_5 %	0.7	-	0.1	0.37-0.49
Kas K_2O %	0.7	-	0.4	0.49-0.58
C/N	20-26	48-50	-	20-28
HCV (kcal/kg)	800-1140	3330	2775	2350

Source: References 11 and 13

The observations in the present study were compared with those reported by Bhide (11) and Vajifdar (14) for Mumbai city (Table 26).

Table 26. Comparison of Chemical Analysis data for Gilbert Hill Solid Waste with values reported for Mumbai City.

	Bhide	Vajifdar	Present Study
pH	6.2	6.8	6.77-6.96
Moisture	49.02	40.94	25.6-41.1
Organic matter	22.57	26.10	
Carbon	12.57	24.55	21.8-25.3
Nitrogen 0.5-0.65	0.54	0.82	0.9-1.11
C/N ratio	23.2	30.0	20.3-27.7
LCV 500-100	1100	-	1141-1666
HCV	2200	-	2347-2445

The standard of living of the people in the slum is relatively low due to their economic status. Therefore many of the things that are used in their daily life is reused or recycled. The recovery of the recyclable constituent occurs in the case of paper, plastic, glass, and crockery. Paper is reclaimed to a very large extent, while the other components are marginally affected. As a result the organic content of the refuse is more.

The calorific value of the refuse ranges between 1120 kcal/kg to 1900 kcal/kg. The refuse cannot give self sustaining combustion reactions due to low calorific value and if incineration is to be carried out additional fuel will be required. The maintenance of mechanical equipment for incineration is expensive, as when compared to composting. The percentage of moisture found in the refuse and the humidity of Mumbai also makes it more conducive for composting.

Composting:

Composting of city garbage and wastes will be more effective in orderly disposal without causing any pollution. Compost conserves the non-renewable sources of energy and plant nutrients are not a pollutant and can be returned where it is needed the most. There are several benefits accrued in agriculture such as improvement in soil structure and texture, increased ammonification, nitrification and nitrogen fixation, crop production etc. Other favourable effects such as detoxification of the effects of pesticides in relation to growth of plants and micro-organisms.

Decomposition or stabilization of organic matter by biological action is natural. This process has been directly utilized in a controlled manner for sanitary disposal and reclamation of organic waste material, with the final product being called 'compost'.

Generally there are two processes: (i) Aerobic decomposition and stabilization and (ii) Anaerobic fermentation. In these processes, bacteria, fungi, molds and other saprophytic organisms feed upon organic materials viz., vegetable matter, animal manure, night soil, other organic and refuse to a more stable form.

Aerobic Composting:

Living organisms decompose the organic material in presence of oxygen. Carbon serves as a source of energy for the organisms and is respired as carbon dioxide. Carbon is not only utilized for energy but also for synthesis of protoplasm for which other nutrients are required including nitrogen, phosphorus etc. Since carbon is required for more than one purpose, much more carbon than nitrogen is required by the organisms. Generally about one-third of the carbon is combined with nitrogen whereas the rest is metabolized to CO_2.

The course of decomposition of organic matter is affected by the presence of carbon and nitrogen. The C/N ratio represents the relative proportion of the 2 elements. The ratio of available carbon to available nitrogen is important since there may be some carbon that is present in a form very resistant to biological attack and therefore is not significant.

More carbon than nitrogen is needed, but if the excess carbon is too great, decomposition decreases when nitrogen is used up and some organisms die. Their stored nitrogen is then used by other organisms to form new cell material, and in the process more carbon is utilized. As a result, the carbon is reduced to a more suitable level while the nitrogen is recycled. When the C/N ratio is above 30, more time is required for the process. An initial C/N ratio of 30 is favourable for rapid composting. A decrease in C/N is a useful index of composting (15).

During the oxidation of carbon to carbon dioxide, a considerable amount of heat is generated. If the organic matter is arranged in a pile, or such that it is insulated, the temperature of the material during the process of decomposition will rise to over 70°C. However, care should be taken that the temperature does not exceed 65 –70°C, since the bacterial activity will decrease and the stabilization process will slow down. At temperatures above 45° C, thermophilic organisms (which can thrive in the temperature range of 45-65° C) develop and replace the mesophilic organisms. Oxidation at thermophilic temperatures takes place more rapidly than at mesophilic temperatures and therefore a shorter time is required for stabilization.

Aerobic decomposition can proceed at any moisture content between 30% and 100%, provided there is adequate aeration. However, a high moisture content must be avoided because water displaces air from the interstices between the particles and gives rise to anaerobic conditions. Too low a moisture content deprives organisms of the water needed for metabolism and therefore inhibits their activity. If the moisture content of the material is too high, straw, soil, sawdust can be added. Also more frequent turning and aeration is effective in promoting loss of moisture by evaporation. When the moisture content is too low, below 40%, water can be added initially and by spraying the material when it is being turned.

One of the important aspects of composting is the destruction of pathogenic organisms. Common pathogenic organisms do not survive temperatures above 65° C. These organisms include *Salmonella typhosa*, *Salmonella sp*, *Shigella sp*, *E.coli*, *Streptococcus pyogenes*, *Mycobacterium tuberculosis*, *Corynebacterium diphtheriae*. In addition, parasites such as *Entamoeba histolytica*, *Taenia saginata*, *Trichinella spiralis*, *Necator americanus* and eggs of *Ascaris lumbricoides* are also destroyed.

Aerobic composting can be accomplished in pits, bins, stacks, piles, and digesters; if adequate oxygen is provided. Turning the material at intervals or other techniques are needed to provide oxygen and maintain aerobic conditions. Compost piles under aerobic conditions attain a temperature of 55-65° C in 1-5 days, depending upon the material and conditions of the composting material. This temperature can be maintained for several days before further aeration. After a time, unless the material is aerated, it becomes anaerobic. Therefore, it is necessary to turn the material.

Anaerobic Fermentation

Organic material is broken down anaerobically. Although the nutrients required by the organisms are the same as in aerobic composting, the organic nitrogen is reduced to organic acids and ammonia. The carbon, which is not utilized by the organisms for synthesis of cell protoplasm, is liberated mainly in the reduced form of methane and only a small proportion of carbon may be respired as CO_2. This process occurs largely in organic material to which oxygen does not have access. Intensive putrefaction is usually accompanied by disagreeable odours of hydrogen sulphide and of reduced organic compounds which contain sulphur eg. Mercaptans.

In anaerobic decomposition, only 5-7 percent of the potential energy is released as heat compared to the aerobic process and most of the carbon is converted to methane. This lack of substantial release of heat is a disadvantage in anaerobic decomposition since, the pathogens are not completely destroyed. Some organisms are destroyed because of biological antagonism and an unfavourable environment. However, the disappearance is slow and a period of as long as 6 months to a year may be required to ensure destruction of *Ascaris* eggs that are very resistant compared to other faecal-borne disease parasites in wastes.

Vermicomposting

Vermicomposting has been advocated as a recycling process without any problem of pollution. Earthworms has been successfully used in several countries elsewhere and in several parts of this country. Earthworms are detritus decomposers and consume large quantities of organic waste. The microflora harbouring in the intestine of the worm and gut enzymes as well as the soil microflora decompose organic substances into simple forms. Earthworms consume food to the extent of 10-30% of its own biomass per day.

They accelerate the process of mineralization of organic matter present in the soil. A major part of mineralization is thought to occur during the passage of soil through the worm gut. The earthworm's gut enzymes are supposed to play a major role in decomposition of the organic material (16, 17, 18).

Nitrogen is mineralized and is shifted to nucleic acids, ammonia, urea and nitrates. Carbon is utilized for respiration by the microorganisms. Acids are condensed to humic acid, and organic phosphorus is converted into its inorganic form by microbial activities. Chemical analysis of castings shows that they contain twice the amount of magnesium, five times as much N, seven times more P and eleven times more K than the surrounding soil.

Passage of soil through the worm gut promotes bacterial growth and the humus creating bacteria *Actinomycetes sp.* thrive in the presence of earthworms. The content of *Actinomycetes sp.* in castings was 6-7 times more than in the original soil.

There are many species and varieties of earthworms with potential utility for organic waste management. They include *Eisenia foetida, Eudrilis engeniae, Perionyx excaatus, Lampito rubellus*. All these species require organic waste. In aerobic composting, aeration is required and this necessitates turning or proper mixing of the waste at regular intervals. In vermicomposting no such provision needs to be made. Each of the earthworm species have their own requirements in terms of temperature, pH and fecundity. *Eisenia foetida* is the most commonly used for managing organic waste. It is usually found in compost and farm-yard manure pits or heaps. It has a wide temperature tolerance and can live in organic wastes with a wide range of moisture content. In a mixed culture it becomes dominant. Reproduction starts 5 to 7 weeks after hatchlings emerge from the cocoons. Vermicomposting of municipal solid waste has been done in three phases.

(i) Collection and preparation which includes separation of various components and shredding into required size
(ii) Composting
(iii) Screening of the compost in order to separate earthworms, vermi-fertilizer and resistant residue.

Vermiculture combines soil processing with waste processing. Simple as well as complex wastes are used and the predominance of aerobic bacteria ensures maximum energy utilization. More bacteria are released which means more bacterial biomass, which speeds waste decomposition to a far higher rate than that is possible under anaerobic conditions. Water is a valuable by-product of waste decomposition by earthworms. Water is released slowly and transported by the earthworms to the root zones of the plants. The living soil produced by the earthworms below the mulch can absorb atmospheric moisture. Such mechanism can dramatically reduce irrigation requirements.

Biological conditioning of solid waste through earthworms has several advantages:

(i) Reducing organic pollution and eliminating foul odour
(ii) Production of environment friendly compost
(iii) Production of vermitin (vermi-protein)
(iv) Development of sustainable agriculture
(v) Wasteland development

Vermicomposting has been used at individual household level in several cities such as Pune, Bangalore etc. Vermicomposting has also been employed to handle biodegradable organic waste in 3 ways:

(i) Bio-processing under a tree
(ii) Bio-processing in a container
(iii) Collection of wastes and central vermi-processing facilities. In addition, vermi-processing toilets have also been used.

Thus, composting has several advantages:

- It minimizes the nuisance to human habitation/colonies and makes the waste safe and hygienic for easy and safe handling by conservancy workers, rag pickers.
- It becomes unattractive to flies, birds and vultures, which can help to reduce the spread of diseases.
- Foul smell is quickly eliminated.
- Pathogens are killed by exothermic heat
- Chances of smoke and fire hazards are minimized.

- Minimizes production and release of gases like methane, ammonia, hydrogen sulphide etc. in the environment.
- Weed seeds, fruit nuts etc. are made not viable.
- Waste material becomes safe for re-transportation etc.
- Products like plastic, metals, rubber, stones, bricks can be recovered and disposed off for different uses.
- The process is completed in approximately 6-weeks.

The process of vermicomposting is known to be slow and very sensitive to high temperature and moisture as well as presence of heavy metals. Vermicomposting can be carried out when the decomposing mass is protected from temperatures exceeding 40°C and in situations where it is not exposed to heavy metals. In Mumbai the moisture content exceeds 60 % in monsoon. So except in monsoon, vermicomposting can be carried out if other factors are looked into.

Composting in the Present Project

In the present project, for the COPRICOL, composting and vermiculture were apparently most feasible. Prior to implementing this at slum level, it was deemed worthwhile to pilot test these.

Pilot Trials

Due to lack of open space in the slum, the pilot testing was carried out in the University premises in order to determine their feasibility for use at slum level. Three methods were tried:

- Vermicomposting
- Aerobic composting with (a) only garbage, (b) with cowdung
- Composting by Excel method

The pilot trails were conducted from October-November 1996 after the monsoons had stopped.

Vermicomposting was tested on a small scale using the earthworm species *Eisenia foetida*. In addition to organic waste, saw dust and cow dung were used. Compost was obtained after a period of 30 days. Another species *Eudrilins eugeniae* was also used for kitchen waste along with garden waste, using 200 gms of earthworms. 20 kg of raw material was used over a 2-month period and approximately 2.5kg vermicompost was obtained. Chemical analysis of the resultant compost using the 3 methods of aerobic composting was carried out. The observations were as follows:

Table 27. Chemical Composition of Compost using Aerobic Composting

Parameters	Excel Technology	Aerobic Composting	Aerobic Composting & Cowdung
pH	7.64	7.45	7.26
% Organic Carbon	7.83	7.87	8.50
% N_2	0.59	0.53	0.49
% available P_2	0.07	0.05	0.05
% Total P_2	0.31	0.28	0.26

Based on the observations, it was deemed worthwhile to first start the aerobic composting. It was decided to try vermicomposting in the slum at a later stage because (I) no space was available to dig pits etc. (2) rodent population is very high (3) people were not willing to try the vermicomposting individually. As such, no one in the slum was familiar with composting and hence they were extremely reluctant to try it. Further, the slum dwellers associate these activities with decomposition, which has a negative image.

Composting in Situ at Slum Level

The amount of waste reaching different communal bins was estimated based on the data obtained for household garbage. In situ composting was planned to be located near these sites, since some open space was available. Keeping in mind the location, financial sustainability and lack of adequate open space; it was necessary to adopt a decentralised approach and to keep the level of mechanization at a minimum.

Aerobic Composting

For the aerobic composting, one open space near a communal pay and use toilet was identified in the Gamdevi Dongri pocket. However, the women residents were extremely resistant and did not allow the S.N.D.T. Team to proceed with the composting, since they did not want any garbage to be heaped up near their homes.

Hence, it was decided to use old metal drums for the purpose. This would conceal the garbage from the public view and would also help to prevent scattering of garbage and keep the surroundings clean.

Two spots were identified for the Excel Technology one at Gamdevi Dongri behind the Community Center and one at Farooqi Masjid behind the communal toilet. One or two collectors carry out the composting process.

20 metal drums were used in one location. Each drum is of 200 liters capacity. Small perforations were made in the drum to allow aeration. One drum could hold 2-3 days garbage collection. The Excel Technology was used:

- Since the housewives do not separate their solid waste, the collector who does the composting separates it. For this purpose, gloves have been provided.

- After putting in the organic garbage, the microbial culture/material called Waste Treatment Substrate (CELRICH Waste Treatment Substrate DF-BC-101) was sprayed. One kg of the substrate was diluted in 20 liters waster. To this 200 ml. of a Defouler solution provided by Excel was added. This amount is used for 1 metric ton of garbage.

- As soon as one drum is filled, the next drum was started.

- After spraying the culture, the treated garbage was left to stand for a week and then the material was turned once every week.

- After 5-6 weeks when the material turned brown, it was pounded, sieved and packaged. Care was taken that the height of the material in each drum was approximately 1 to 1½ meters.

Twenty drums were used because all drums would be filled in a 6-week period and in the first drum, the compost would be ready, allowing the drum to be reused. Once the compost was ready it was dried, powdered, sieved and packaged. The coarse material was mixed with fresh incoming waste and retreated.

Since this was not part of the garbage collectors working in the COPRICOL, an additional sum of Rs. 250 per month was given in order to carry out the work.

Composting using Excel Technology

The first batch of compost was analyzed for chemical constituents and also for its microbiological profile. The results are summarized in Table 28

Table 28. Composition of Compost and Microbial Profile

Parameters	Value	Parameter	Value
pH	8.6	Total bacterial count	1.7×10^8
% Organic Carbon	21.93	Actinomycetes	Not observed
% Nitrogen	0.9	Fungal Count	3×10^4
% Total Phosphorus	0.44	Azotobacter	22×10^4
% Calcium	0.184	Root nodule bacteria	5.2×10^4
% Magnesium	0.098	PSB	Not observed
% Potassium	0.81	Pathogens	Present ++

Since pathogens were found, it was recommended that recomposting of the material be done. After discussion with the garbage collector it was found that:

(1) The height of the material in the drum reduced after a few days and did not reach 1 meter.

(2) The moisture content of the material was much less than recommended.

Hence the collectors were instructed to pay attention to these 2 aspects and in order to achieve a height of 1-1½ meters, it add more organic solid waste to the amount collected in a 48 hour period. The collectors were trained again to judge the moisture content. Each collector was provided a calendar in which the days when the compost material is turned is entered. The supervision and monitoring of this activity is done by some RCVs who chose to undertake this responsibility. The details of the training inputs given to the collectors are presented in Appendix IV.

Using the overall mean value for solid waste generated per family per day, it was estimated that the amount of solid waste collected at these sites may be as follows:

Table 29. Amount of Garbage arriving at Selected Disposal Points

Location/Pocket	Approximate number of families using communal waste bin	Amount of garbage collected for composting through COPRICOL (kg)
Juhu Galli (Farooqi Masjid)	2000 – 2500	1360
Gilbert Hill	800 – 1000	480
Gamdevi Dongri (1 site at Community Centre)	600	470
Khan Mohammed Chawl (1 entrance to the slum in the Patkar Compound area)	300	300
Patkar Compound	1000	740

**** This is the total amount of solid waste arriving in a day. The number of families participating in COPRICOL at the time of the first cycle of composting was approximately 9000.***

In the Farooqi Masjid composting alone, from 2 cycles 45 –days a total of 189 kg of compost was obtained. Of this 45 kg was taken by the local residents of Farooqi Masjid for their greening effects. Ninety kg was given to the University's garden department in exchange for plants which were used in the greening efforts. The remaining compost was sold within the campus @ Rs. 10 per kg. Currently, for purposes of sustainability, upon the advice of the consultant, the compost is sold at Rs. 25/- per kg.

Initially composting was started at Farooqi Masjid and near the Community Centre at Gamdevi Dongri. Later it was expanded to more sites: two at Gamdevi Dongri, one at Patkar Compound and the 3rd behind the toilet at Gilbert Hill.

Of the 6 sites where Excel Technology is being used for composting, it is now continued at only 2 sites: Farooqi Masjid and at the Community Centre in Gamdevi Dongri. The collectors are paid an additional Rs. 250 per month to undertake the composting work. At the other sites, pilferage of drums a strong resistance from the community, has led to stopping the Excel Process. Vermi-composting was also initiated on a pilot basis at the Gamdevi Dongri Centre, using 2 kits procured from the Garden Dept. of Godrej India Ltd. The vermi-composting was carried out in plastic buckets (each of which cost Rs. 675) and compost was ready in April 98. As per the instruction given, partially decomposed organic material has to be used. Therefore, the partially decomposed material from the Excel Technology process was used. A total of 24 kg compost was obtained. The composition of the 2 types of compost is presented in Table 30.

Table 30. Composition of Compost using Excel Technology and by Vermicomposting

Parameters	Excel Technology	Vermi Compost
pH	8.60	-
% Organic Carbon	21.93	15.42
% Nitrogen	0.90	1.36
% available Phosphorus	-	0.61
% Total Phosphorus	0.44	2.58
% Calcium	0.184	0.385
% Magnesium	0.098	0.254
% Potassium	0.81	0.72
Microbiological Quality		
TBC	$1.7x10^8$	$3.8x10^8$
Actinomyces	Not observed	$2.7 x10^3$
Fungal Count	$3x10^4$	$4.2x10^3$
Azotobacter	$22 x10^4$	$6x10^4$
Root nodule bacteria	$5.2 x10^4$	$2.1 x10^3$
PSB	Not observed	$1.9 x10^2$
Pathogens	++ (Salmonella sp Shigella sp Pathogenic fungi)	+ (few observed)

Groups of tests used to judge the compost are:

(a) Tests of sanitary quality of the compost by testing for presence/absence of pathogens and parasites.

(b) Estimating the amount of nitrogen, phosphorus, potash, other nutrients, the C/N ratio and the compost value.

Comparison of the chemical parameters of the compost obtained in the present project, suggests, that the vermicompost has more amounts of available phosphorus, calcium as well as nitrogen. Microbiologically, the vermicompost is apparently safer to handle. Since the aerobic compost was found to have pathogens, it was recomposted to ensure destruction of the pathogens. The collectors who are involved in composting were given a reorientation about the composting process and the do's and don't's. The vermicompost had a brownish-black colour, was more moist and did not flow easily. The compost obtained using the aerobic process was more Grey in colour, flowed easily and was more dry compared to the vermicompost.

Most soil organisms have a C/N ratio of between 15:1 and 30:1, so it is generally accepted that if compost is added to the soil, the C/N ratio should be below 20:1. If it is above 20:1, at high rates of application, microbiological activity will immobilize the available nitrogen in the compost causing a nitrogen deficiency. Compost made from household wastes and sewage sludges can vary greatly in their composition, due to the differing constituents of wastes and sludges form different areas (15).

The C/N ratio of the compost obtained using the Excel Technology was 24.4:1 and that of the vermicompost was 11.34:1. These differences and the differences in other chemical parameters may be attributed to the variability in the constituents of wastes. From the financial aspect, the recurring costs for vermicomposting are likely to be much less than those using Excel Technology

However, the Godrej vermicompost kit was rather expensive when wider application and extension of its use at individual family level was considered. The S.N.D.T. **team therefore held dialogues with the community to start vermicomposting at 3 levels:**

- **At individual level**
- **Group level : where 10-15 families in a lane would use one kit**
- **Community level**

Among the different pockets, the Patkar Compound and Gamdevi Dongri have relative advantages

(i) availability of some open space to try out the community level composting.
(ii) a relatively high level of motivation and willingness to undertake the responsibility for supervision, maintenance etc.
(iii) cooperation given by the local leaders in implementation of the scheme.

Hence, the RCVs from these 2 pockets were given an orientation, using a videocassette by M/s. Biosphere Ltd. This company supplies kits for all 3 levels and also undertakes the training. Simultaneously the project staff spoke to local leaders, elected representatives and concerned officials at the Municipal Corporation's ward office, seeking permission to construct the facilities for community level composting.

Community Level Composting

In Patkar Compound, community level composting has been started at 2 sites under the supervision and maintenance by RCVs and the Youth Group. However, until the NHC and the Youth Group have accumulated some funds, SNDT has been requested to pay a stipend of Rs 250 per month for the composting and to help provide the market links for sale of the compost. The Municipal Primary School is also located at Gilbert Hill. The Principal of the School was approached and vermicomposting has been started in the school, involving the teachers and the students who will maintain and carry on the activity. In Gamdevi Dongri, the elected representative has volunteered to construct the facility for vermicomposting to start at one site.

Group Level Composting

In the Gilbert Hill area, one group level vermicomposting has been initiated and the Mahila Mandal of Gamdevi Dongri has started one at the Community Centre. Another group in Gamdevi Dongri has expressed in interest in starting the group vermicomposting. A wooden box with vermicasts and other material has been provided to each group. These have been procured from M/s Biosphere Products who have also demonstrated the process to the RCVs who are involved.

Individual Level Vermiculture

The project staff has been motivating women to take up this activity individually. The kit is an LDPE bag provided by Biosphere Ltd. The cost of each individual kit is Rs 100. Those women who are interested have been given these bags utilizing project funds. Initially 2 women from Patkar Compound started the vermicomposting. Later 4 women from Gamdevi Dongri expressed an interest and started. Within a period of 3 weeks, there has been a demand for the individual level kit from 25 more women. It is hoped that this will have a multiplier effect. However, in pockets like Dhangarwadi, space is tremendous constraint and this cannot be implemented. Further in all pockets, residents require to be convinced by the project staff that in the vermicomposting process there will no foul odour and that it will not attract rodents.

ENVIRONMENT EDUCATION

The major task was to make the residents of Gilbert Hill Gamdevi Dongri realize that environmental sanitation means more than removal of the waste from their own homes, it meant not only physical removal of waste from one point to another, but also establishing an effective community-oriented management system. The areas of focus were:

- ***Changing attitudes and increasing awareness on waste and its many dimensions***
- ***Reducing the amount of garbage scattered around not only at collection points but also through the slum area in general especially in the drains.***
- ***Reducing the dependence on municipal authorities.***
- ***Recognizing the need for the community itself to participate actively, take the initiative, evolve and take the responsibility to manage a collection system.***
- ***Recognizing the need for segregation of waste into organic and non bio-degradable components.***
- ***Starting new initiatives in their own slum such as treatment/reduction of waste at source.***

The project had to address itself to a problem of gaps in service resulting from a combination of inappropriate technology, poor staff management and lack of public cooperation.

An important objective that also required constant thought and attention was not just bringing in the local community/community structure for introducing and managing the scheme, it also included addressing the issue of the scale of activities required and programme sustainability.

The education inputs had to be addressed towards changing deeply ingrained habits among the people.

The education efforts therefore were a continuous process which, began with the project and continued throughout the project period.

The education was targeted largely towards the family per se and women of the community since they are the members who handle the solid waste and are often the decision-makers about its disposal. However it was vital to address, educate and building the capacities of the members of the community structure, the local leaders, elected representatives and youth as well as children. Along with this, advocacy with the municipal officials was also necessary.

For each group the approaches used were different. During the three-year project of education and sensitization of women and the community structure was an important and major activity.

Educating the Community:

This was done through mohalla meetings and discussions. Prior to starting the COPRICOL, meetings were held with small groups of women in each pocket.

In these meetings, several issues were discussed: The first discussion focussed on the satisfaction of the residents with the current management of solid waste, and the need to seriously address this issue. The topics which were included in the discussion were:

- ***Current status of environmental sanitation in their pocket.***

- ***Implications in terms of social aspects and health risks. If the participants did not/were not able to link morbidity and poor environmental sanitation, these were emphasized by the project staff. They were also reminded about the plague score that had occurred, a short time prior to initiation of this project.***

The women perceived that malaria was one illness linked with poor sanitation. The project team however had to emphasize the problem of diarrhoea, worm infestation especially among young children. In addition the economic implication of frequent illness were included.

- ***Existing strategies/systems for waste management and where do the gaps exist.***

- ***Possible solutions and the need to reduce dependence on municipal authorities on the one hand and for the community to take up responsibility and play an active role.***

At this juncture, the possible value of solid waste was discussed, the possibilities of recycling on the one hand, and composting on the other. Further, the need to work at reduction of the waste at source i.e. in situ within the slum was explained and the discussion(s) usually ended with the project team explaining the objectives of the project, to duration and the need for self-sustainability. The COPRICOL mechanism was explained and wherever the women gave a positive response, the COPRICOL was initiated.

After this, the education took the form of advocacy and resensitization. This was done through home visits and discussions with individual families as well as group meetings. The forms was done by the community organizers of the IDRC sponsored project teams as well as the Urban Basic Services of the poor and the Resident Community Volunteers in their respective pockets.

Advocacy was required for 2 aspects:

(1) Segregation of waste at source:

Most residents except in part of 2 pockets in Janata Colony and Patkar Compound were willing to hand over garbage to the Collector but the segregation required additional effort and they did not perceive any benefits to themselves.

(2) Payment of the monthly contribution:

For segregation, in the pilot phase, daily home visits were made by the project staff and mahila mandal members to encourage and motivate women to separate the inorganic and biodegradable solid waste. For this purpose, leaflets were also distributed. However, as the project expanded its coverage of families, home visits to motivate housewives for segregation by project staff was not feasible, although the inputs for this continued at mohalla meetings and at the monthly monitoring/ review meetings with members of the community structure.

(3) The ingrained habits of disposal and mindset/recalcitrant attitudes of slum dwellers necessitated more interpersonal communication.

Therefore less emphasis was placed on audio visual aids etc and more on personal contact, rapport building since the efforts had to be directed towards motivation, persuasion and counseling. These efforts were put in continuously throughout the project is order to persuade the residents to segregate and pay their monthly fee/contribution. In some areas where the residents refused to participate in the COPRICOL, repeated door-to-door visits were made and mohalla meetings were held to persuade them.

Such mohalla meetings and intensive interaction became necessary whenever the garbage collectors left the project without prior notice and new men were joined after a gap of a few days. Residents had to be coaxed and persuaded to participate again in the COPRICOL.

At these meetings, the need for the community to participate actively to monitor and supervise the collector and to identify new collectors whenever necessary as well as to ensure that those collectors who are present would cover those families in pockets where a collector may be absent.

Similarly, these meetings were conducted before composting and greening was started. For the latter, the community was asked to contribute in terms of labour i.e. manpower and/or material. They were also asked to take over the maintenance of the small garden plots once the plants had been sown.

Educational inputs were given about the impact on poor sanitation and hygiene on the health status.

Educational sessions were first conducted for the RCVs wherein they were given inputs about transmission of disease, common diseases that are encountered is their slum and the effect on health and nutritional status. The interrelationship between sanitation, infection and malnutrition were explained by a doctor and what the residents should do to prevent these. The RCVs in turn were asked to explain these to their neighbourhood groups i.e. the 15 to 40 families they represented.

In addition, the project teams of the two IDRC-sponsored projects and the 4 UBSP project staff, also conducted mohalla meetings with women on the same topic.

Orientation sessions were also held with RCVs about vermi culture. This was done first by showing them a video film on vermi composting, followed by a discussion about their opinions, clarifications about doubts they had. The RCVs were then given time to think about whether they would like to adopt this technology after discussion with the residents.

In addition to this, inputs for awareness creation were given through:

- **A rally/march throughout the slum every year on World Environment Day. All RCVs, members of the Mahila Mandal (registered women's groups) and children participated.**
- **Street plays performed in various pockets. In the first year, 2 street plays were performed by NGOs. In the second and third year, students who were doing their field work in this slum (as a part of their academic coursework) performed street plays. In year III, the RCVs of Patkar Compound performed a play with the script being written by themselves.**
- **Distribution of posters and baflets.**
- **Exposure visits wherein some active and motivated RCVs were taken to another UBSP town to enable interaction.**
- **Poster painting competitions organized for adolescent girls.**
- **Competition among the various pockets and NHCs for cleanest mohalla.**
- **Children's Camp on Environment and Health.**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महिला मण्डल
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Leafy vegetables and other plants grown by slum residents

Capacity Building of Community Structure:

In this project, the **efforts were directed towards sensitizing the community on the one hand and on the other, working towards self-sustainability of inputs by the NHCs.**

The latter was essential in order to foster and inculcate to make them assume the responsibility for the broad issue of solid waste management in general. This included not only the COPRICOL, but also the indiscriminate disposal of feces, maintenance of existing toilets and construction of new ones.

This was done through weekly review meetings, a gradual transfer of responsibility for monitoring and supervision and the authority to make decisions about the system, payment of the collector. In addition guidance was given about how to approach and (whom to approach) at the local ward office level. While the COPRICOL was being put in place, the aim was to have privatization to some extent in the collection of waste from residents and its transportation to the Communal bin. However the scheme did not at any time eliminate the need for municipal services. The NHCs were therefore sensitized to the need for the community to independently sustain a waste collection and reduction system and to liaise with the municipal office for waste removal and disposal. The aim was to foster and forge good wording relationships between the community structure and the appropriate departments of the local Municipal Ward Office. In this process, the staff was able to motivate some youth in 2 pockets: Patkar Compound and Farooqi Masjid.

In Patkar Compound the youth group have taken the issue of Environmental Sanitation and Health for action. They are today running and maintaining a newly constructed pay and use toilet in their area. They have also planted trees around the toilet and maintain the plants.

Similarly in the Farooqi Masjid the youth group have taken over the maintenance of the small green plots created around the communal toilet after they were created.

Advocacy with decision-makers:

Simultaneously, the project staff has been advocating the need to focus on environmental sanitation to local leaders and elected representatives*. Thus for construction of vermicompost pits and for the construction of beds and the wire/grill enclosures, elected representatives contributed in the form of material or financial support upto approximately 50% of the expenses.

The role of S.N.D.T. was to sensitize the elected representatives, as well as the local ward level Municipal officials to the prevailing situation of environment and sanitation in the slum, the needs of the slum dwellers and the gaps in services. With the elected representatives, advocacy was done mainly to motivate them to utilize some of the Councilor's funds for the inputs required for environmental sanitation.

With ward level officials, the objective was to improve services especially with reference to:

- **waste removal and transport out of the slum.**
- **maintenance of toilets**
- **repair and construction of new toilets**
- **repair/construction of garbage disposal receptacles/facilities**
- **cleaning of drains - small and large**
- **issuance of NOC for construction of garbage receptacles, beds for greening and for vermicomposting**
- **tree guards for the plants**
- **plants for the greening initiative**

Advocacy with local leaders was extremely essential since these leaders control the use of open space in urban slums. Also land prices are at a premium. Therefore, it was necessary to convince these leaders to allow the greening to be done. In almost all cases, the decision-makers could be influenced positively by the S.N.D.T. Team.

GREENING/CITY FARMING

Besides the COPRICOL and COPRICOL-WRR, the project aimed at introducing city farming to the residents of Gilbert Hill. Typically in Mumbai, in a slum, most open spaces are utilized for residential or commercial purposes. The first task was therefore to identify open space for growing plants and/or trees.

However, lack of space made it generally difficult to plan on large scale. The aim in understanding this activity was two-fold: (a) to improve the aesthetic appearance of the slum and try to introduce green areas for environment improvement and (b) to attempt enhancing the availability of vegetables, if possible to the urban slum families.

As trees mature, the beneficial value becomes greater. This involves not only aesthetic values but may also help in environmental control. Plants extract pollutants directly from the air, and by stimulating turbulence, they increase the sedimentation of dust and aerosols. Noise levels are also reduced by mature plants. Plants also release oxygen, humidify the air and influence the climate. Green areas have a different microclimate from that of paved and built-up areas especially in terms of temperature, moisture and wind velocity.

Accordingly, the concept of greening and city farming and the importance of these were discussed with the RCVs. **Two approaches were used:**

i) **Greening of open spaces (community ownership and maintenance).**

ii) **Cultivation of plants at family level including cultivation of vegetables/green leafy vegetables for consumption.**

Greening of Open Spaces:

The RCVs were asked to identify potential sites where greening could be done and to discuss the possibility of using this space with the local leaders. Informing the local leaders and obtaining their consent was crucial because they often control the open space in the slum and generally considerable amount of money is charged for use of such space if a house or shop is located there.

The first NHC who came forward was the one at Farooqi Masjid. Before the greening could be done, **the project team mooted that:**

- **Some contribution should come from the community, so that 30-50 % of the cost is borne by the community for construction and fencing.**
- **Maintenance of plants will be the responsibility of the community.**

All RCVs agreed and the first efforts at greening were started in October-December 1996. Two small open areas adjacent to the 2 walls of a 60 - toilet communal facility were identified. at the side and back of the toilet by the RCVs at Farooqi Masjid. The RCVs obtained some contributions in cash and part of the materials required, such as bricks. sand. cement and wire mesh from the local shopkeepers. Labour was donated by the residents themselves. The RCVs initially took up the responsibility of watering and maintenance. Later on, in this pocket, the youth groups volunteered and have taken over the task

In 1998, the Youth Group asked that greening be done in the front portion of the toilets as well which was undertaken and completed.

Greening around toilets and public service facilities such as police station


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Following the example set by the Farooqi Masjid residents, the local leaders in Wireless Road planted trees along the roadside in their pocket.

In Patkar Compound, greening was undertaken around a newly constructed toilet maintained by the Youth Group as well as a Police Station located in the area.

In Gamdevi Dongri, initially greening had been done in a small patch outside one of the communal toilets. However, goats, which roam freely throughout the slum, ate the plants. After 2-3 repeated attempts, the Project Team approached the local political leader who located another spot for greening since there is tremendous resistance also from residents. This was also the pocket where residents did not allow the project team to indicate composting.

In all spots where greening has been done, a mixture of plants/trees have been used. Fruit trees as well as flowering plants, which are not difficult to maintain, were chosen. Also some plants, with flowers having good scent were chosen especially for spots near the toilets.

The trees and plants include:

Farooqi Masjid Area: (1 site)	Patkar Compound (2 sites)	Gamdevi Dongri (3 sites)
Coconut (*Cocos nucifera*) **Papaya (*Carica papaya*)** **Neem (*Azadirecta indica*)** **Tulsi/Holy basil (*Ocimum sanctum*)** **Hibiscus (*Hibiscus sinensis*)** **Rose** **Creeper / vines** **Raatrani (*Sestrem nocturnum*)**	**Chickoo/Sapota (*Achras sapota*)** **Roses** **Chameli (*Jasminum officinale*)** **Mogra (*Jasminum sambac/ arabicum*)** **Raat rani (*Sestrem nocturnum*)** **Mango (*Mangifera indica*)** **Jambul (*Syzygium cumini*)** **Orange (*Citras aurantium*)** **Sada Phuli (*Vinca rosea*)**	**Coconut (*Cocos nucifera*)** **Papaya (*Carica papaya*)** **Mango (*Mangifera indica*)** **Holy basil/Tulsi (*Ocimum sanctum*)** **Other decorative plants**

The general procedure, women were asked to follow was:

1. Use any container which can be recycled and make small perforations
2. Fill about 2-3 inches of bagasse (if available)
3. Add soil, up to approximately 40 % of the height of the container.
4. On this, daily add organic/kitchen waste material for a period of 8 days.
5. Add more soil and whatever is preferred.
6. Water the plant daily.

In order to protect from hen's etc. women have been told to use fine wire mesh/netting to protect from rodents, use of rodenticide was recommended.

Several women individually and jointly have started cultivation of:

Coriander leaves	(*Coriandrum sativum*)
Fenugreek leaves	(*Trigonella foenum graecum*)
Spinach	(*Spinacia oleracea*)
Ladies finge	(*Abelmoschus esculentus*)
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AIR POLLUTION:

Air Pollution is generally a condition of disequilibrium air caused due by the introduction of foreign elements from natural and man made sources to the air so that it becomes injurious to biological communities.

Air Pollution may be personal, occupational or community air pollution. Exposure of an individual to dust, fumes, smoke, smog and gases may be regarded as personal air pollution. The type of exposure of an individual to potentially hazardous concentration of aerosols, vapours and gases in his working environment is known as occupational air pollution. Community air pollution involves pollution from a variety of sources and contaminants and factors which cause adverse social, economic and health effects. Community air pollution not only affects many individuals, but it can also exert a significant impact on man's total environment, including plants, animals, buildings, property and even the wealth.

The most important gaseous air pollutants are carbon monoxide, chlorine, halogenated solvents, hydrocarbons, hydrogen sulphide, nitrous oxide and sulphur dioxide.

Various industrial installations such as asphalt plants, boiling and heating installations, cement manufacturing, fertilizer manufacturing, mineral acid manufacturing, paper and pulp manufacturing, thermal and nuclear power plants, sewage treatment plants, engineering workshops etc. form stationary sources of the urban air pollution. Automobiles such as cars, scooters, motors, trucks, buses moving on the urban roads form the mobile sources of air pollution.

Major sources of Air Pollution include:

1. Natural sources: The natural sources of air pollution are volcanic eruptions releasing poisonous gases such as SO_2, H_2S, CO etc., forest fires, natural organic and inorganic decays or regenerative decay, marsh gases, deflation of sands and dust, extra terrestrial bodies, cosmic dust, soil debris, comets and fungal spores. All these are produced naturally and released in the air, making it foul and injurious to health.

2. Manmade sources: Man made sources such as increase in pollution, deforestation, burning of fossil fuels and fires, emissions from vehicles, rapid industrialization, agricultural activities and wars, are the major causes of air pollution.

Air pollutants are usually divided into two general categories as

i) Primary pollutants
ii) Secondary pollutants

Primary pollutants are those which are emitted directly from their sources and Secondary pollutants are formed in the atmosphere by chemical interactions among the primary pollutants with other normal atmospheric constituents.

Typical primary pollutants include particulate matter such as fly ash, smoke, dust, fumes, mists, sprays and gases such as SO_2, H_2S, NO, NH_3, CO, HF as well as vapours of aliphatic and aromatic hydrocarbons etc.

Secondary pollutants include SO_3, NO_2, photochemical oxidants, such as peroxyacyl nitrates, Ozone, aldehydes, ketones as well as various sulphates and nitrates, salt particulate etc.

Of the large number of primary pollutants emitted into the atmosphere, only a few are present in sufficient concentrations to be of immediate concern. Carbon dioxide is generally not considered an air pollutant. but because of its increased global background concentration its influence on global climatic patterns is of great concern.

Common air pollutants, their sources and pathological effects on man are summarized herein.

Pollutants	Sources	Pathological effect on man
1. Hydrogen Sulphide	Refineries, chemical industries and bituminous fuels.	Causes nausea, irritate eyes and throat.
2. Sulphur dioxide	Coal and oil combustion	Causes chest constriction, headaches, vomiting and death from respiratory ailments.
3. Nitrogen oxides	Soft coal, automobile exhausts	Inhibits cilia action so that soot and dust penetrate far into the lungs.
4. Carbon monoxide	Burning of coal, gasoline, motor exhausts.	Reduces oxygen carrying capacity of blood.
5. Ammonia	Explosives, dye making, fertilizer plants and lacquers.	Inflames upper respiratory passages.
6. Aldehydes	Thermal decomposition of oils, fats or glycerols.	Irritate nasal and respiratory tracks.
7. Suspended particles	Incinerators and almost every manufacturing process.	Cause emphysema, eye irritation and possibly cancer.

Effects of air pollutants

The direct human health effects posed by air pollutants vary according to the intensity and duration of exposure. These pollutants directly affect the respiratory, digestive, nervous and cardiovascular systems. Increased deaths, diseases and disability have been associated with elevated levels of sulphur dioxide and suspended particulate matter. Carbon monoxide is able to displace oxygen in the blood. The affinity of carbon monoxide for hemoglobin is 250 times greater than that of oxygen. It causes severe headache, dizziness, nausea, mental retardation, and neurological disorders. Oxides of nitrogen and ozone affect seriously. The respiratory system, irritate the eye, nose and throat. Lead affects bone marrow, hinders liver, heart and kidney function, and causes neurological damages and mental disorders in children.

Hydrogen Sulphide (H_2S): H_2S is produced mainly by bacterial decomposition of organic matter. H_2S does not pose a widespread air pollution problem, but localized problems may be severe, mostly sulphides cause odour nuisance when present even in minute concentrations. H_2S causes headache, nausea, collapse, coma and finally death even at 1-3 ppm. Hydrogen sulphide at 5ppm affects the digestive system destroying appetite. An exposure of 150 ppm of H_2S creates conjunctivitis and irritation of mucus membrane. Hydrogen sulphide gas rapidly passes through alveolar membranes of lungs and penetrates in blood. It causes death due to respiratory failure. Short exposure, even for 10-30 minutes at 500 ppm of H_2S causes colic diarrhea and bronchial pneumonia.

Suspended particulate matter (SPM):

The effects of SPM are largely dependent on the particle size. Air borne particles i.e. dust, soot, fumes and mists are potentially dangerous for human health. Aerosols less than 1 μ may reach the alveoli of lungs and damage lung tissues. Lead, the most serious pollutant released from automobile exhaust is reported to have detrimental effect on children's brains. Lead, interferes with the development and maturation of red blood cells. Silicosis, a chronic disease of lungs, is caused by inhalation of dust containing free silica, SiO_2. The acid particulates and aldehydes cause irritation of eyes, nose and throat. Beryllium compounds like BeSO4 and BeCl2 cause acute inflammation of the lungs.

Nitrogen oxides:

An exposure of 50 to 100 ppm of nitrogen dioxide causes inflammation of lung tissues for 30 to 50 minutes for a period of 5 to 8 weeks. Nitrogen dioxide has irritating effects on mucous membranes. Higher doses of nitrogen dioxide cause bronchitis and respiratory problems. Nitrogen dioxide is reported to be a pulmonary irritant whose excess concentration causes pulmonary hemorrhage. Nitrogen dioxide also lowers the resistance to influenza and irritates the eyes. Nitric, nitrous acid and several nitrates cause respiratory, digestive and nervous ailments. Higher levels of oxides of nitrogen cause gum inflammation, internal bleeding, pneumonia, oxygen deficiency and lung cancer etc.

Sulphur Dioxide (SO_2):

SO_2 is absorbed by the nasal system, leading to swelling and stimulated mucus secretion. It causes intense irritation, even at 2.5 ppm level to eyes and respiratory tract. Lung cancer is known to result due to raised levels of SO2 in the atmosphere. SO2 inhalation causes the symptoms of bronchitis, emphysema and other lung diseases. Increased concentration of oxides of sulphur causes acute and chronic asthma. Higher concentrations of SO_2 induce desquamation of the surface epithelium in the mucosal cilia, which protect the respiratory system.

Carbon Monoxide (CO):

All gaseous pollutants cause severe damage to the respiratory system. But the adverse effects of CO in the human body are unique. It reacts with the haemoglobin of the red blood corpuscles forming a stable coordinated complex, called carboxy-haemoglobin, which restricts transport of oxygen from lungs to cells. CO causes respiratory failure, headache, fatigue, coma, drowsiness and even death.

Ambient Air Quality:

The quality of ambient air is of great importance because measurement of ambient air quality gives information regarding effects on health.

Air quality impacts at the disposal sites are chiefly due to the emission of pollutants due to widespread 'on site' burning and diffusion of products of natural degradation of refuse. The more prominent and harmful of these emissions are smoke, soot, SO2 & CO2 generated due to burning. Inhalation of these pollutants causes respiratory ailments and eye irritation.

The air pollutants expected in natural emissions are carbon dioxide, methane, hydrogen sulphide and ammonia. These gases in higher concentration at the disposal sites are generally expected to be low.

Air Quality in Gilbert Hill:

In the present project therefore, observations on air quality were made. Measurements consisted of suspended particulate matter and hydrogen sulphide.

Sampling:

A high volume sampler Model NPM-HVS was used to collect the samples of SPM and H_2S at a flow rate of 1.1 - 1.2 m^3/min. using standard methods suggested by the Central Pollution Control Board (CPCB). Monitoring at each site continued for 24 hrs duration. The samples were brought to the laboratory and analyzed within reasonable time and with due care.

Sampling of 13 different points/locations was done which were classified as: greening sites, dumpsites, vehicular sites and toilet site. The mean values observed for these are presented in Table 31.

Table 31. Observations on Air Quality at Gilbert Hill Slum

Site	H_2S (ug/m^3)			SPM (ug/m^3)		
	Mean	**S.D.**	**C.V.**	**Mean**	**S.D.**	**C.V.**
Vehicular movement	0.14	0.02	0.14	69.81	5.29	0.08
Greening	0.14	0.01	0.09	48.27	1.01	0.02
Toilet	0.22	0.02	0.10	50.62	6.95	0.14
Dump site	0.14	0.02	0.14	59.95	2.48	0.04

The observed values of suspended particulate matter (SPM) are much below the permissible limit of 140 (μg/m^3) given by the Central Pollution Control Board. The SPM was found to be highest at the site where there is vehicular movement with a concentration of 69.81 (μg/m^3) and the least at the site of greening where it is 48.27 (μg/m^3). Similarly, the concentration of hydrogen sulphide (H_2S) gas was found to be less than the international background values for urban areas which is 1 (μg/m^3). H_2S concentration was higher near the toilet area about 0.22 (μg/m^3) whereas its concentration remained at almost similar levels in the rest of the areas 0.14 (μg/m^3).

Greening may have a positive effect on the air quality. However, greening was completed towards the end of the project and could be undertaken in limited areas where small open spaces were available for use. Hence it is not possible to determine at this juncture, whether greening had any beneficial effect in this area.

COSTS AND BENEFITS:

Collection and analysis of data on programme costs can provide considerable useful information on services of all kinds. It can indicate the size of funds from all sources likely to be required to continue programmes, help to assess the use of personnel in delivering the services and the efficiency of putting supplies, transportation resources and other inputs to work.

"Any economically efficient strategy needs to take into account the relationship between the cost of attaining each increment of improvement and the benefit obtained from that increment." It could be measured in terms of improved health or reduction in damage.

In this project, there was mainly 2 systems setup in the slum: COPRICOL and COPRICOL - WRR. The cost analysis was done for each of these separately. Classification of costs was done by inputs. Wherein the costs were categorized as Capital Costs and Recurrent Costs.

Capital Costs included: Equipment, training (non-recurrent), consultancy, construction costs etc. and recurrent costs included personnel, supplies, operation and maintenance of vehicles. An attempt has been made to include all the relevant functions/activities, inputs, funds.

In case of trolleys for garbage collection the working life of the equipment was considered. Based on the experience in the slum the working life of trolleys was estimated to be one year.

The cost-benefit analysis of the entire project was done both quantitatively.

The quantitative analysis looks at the project in terms of money and was done separately for three areas, namely, Gamdevi Dongri, Patkar Compound and Bhavans and Dhangarwadi. In this analysis the COPRICOL and COPRICOL-WRR systems were compared. The costs included the amount of money spent on the trolley, garbage collectors, dustbins, salary of the supervisors, travelling, trolley repair and consultancy in COPRICOL system. Whereas in the COPRICOL-WRR system of analysis the above costs along with the cost of culture, drums, labour cost, shovels sieves and the construction of pit for composting were taken into account.

The benefits included the monetary gains obtained from reduction in morbidity, segregation and resale of recyclable solid waste, generation of employment and sale of compost in the COPRICOL-WRR system. Reduction in morbidity was calculated by finding out the difference in the rate of morbidity for 2 successive years per person per day in percentage. For the COPRICOL system the above benefits except the sale of compost were considered. Morbidity was examined by calculating and comparing the morbidity in 200 families included in the study by simple random sampling. Morbidity data was collected one year apart, baseline data being collected after the COPRICOL was started in most areas of the slum and towards the end of the project. Morbidity data was collected at both time points, post-monsoon, in the months of October-November. The data was examined in terms of illness episodes in different age groups. The results obtained are summarized in Appendix V.

It was found that COPRICOL-WRR system was more beneficial than the COPRICOL system. This was due to the fact, that in COPRICOL-WRR system, the projected sale of compost has been considered.

In addition to this, the qualitative aspect was examined in terms of improvement in the quality of life of the slum dwellers. Qualitative analysis of these areas showed that there is a marked difference in the attitude of the people living in the slum towards the Solid Waste Management Project. More people are now becoming sensitized about the sanitary conditions in the slum. The environmental quality has the potential to be improved considerably as compared to the beginning of the project. In the areas where greening was done, the air quality appears to be slightly improved, as is reflected by that the decrease in concentrations of Suspended Particulate Matter (SPM) and Hydrogen Sulphide (H_2S).

It is also found that some households segregate the waste into dry and wet wastes. They then sell the recyclable which becomes a source of income for them. The biodegradables are also used to generate compost, which is either sold or used in the greening process.

Earlier children used to defecate in the open areas near the home or toilet, the roadside or the open drains, but now the people are more aware about the ill effects of such behaviour. More toilets were constructed due to the action taken by the people. As a result of these actions, there is a reduction in the morbidity among the people. More and more people have become involved and some of them are employed as supervisors. This project has also managed to generate some employment.

Table 32: Costs and Projected Benefits in three areas of the slum for the COPRICOL.

	Gamdevi Dongri	Patkar Compound	Bhavan's & Dhangarwadi
Capital Costs	**Costs: (per day)**		
1. Trolley/day	Rs. 13.66/-	Rs. 4.27/-	Rs. 2.56/-
2. Payment to the garbage collectors	Rs. 236.71/-	Rs. 78.9/-	Rs. 65.65/-
3. Dustbins	Rs. 58.45/-	Rs. 4.09/-	Rs. 11.40/-
4. Salary of supervisors	Rs. 263.01/-	Rs. 131.51/-	Rs. 98.63/-
5. Travelling	Rs. 60/-	Rs. 60/-	Rs. 60/-
6. Trolley repair	Rs. 3.54/-	Rs. 16.19/-	Rs. 1.68/-
7. Consultancy	Rs. 45.70/-	Rs. 45.70/-	Rs. 45.70/-
TOTAL COST	**Rs. 681.07/-**	**Rs. 340.66/-**	**Rs. 285.62/-**

Projection : Benefits (per day)

	Gamdevi Dongri	Patkar Compound	Bhavan's & Dhangarwadi
1. Reduction in morbidity	Rs. 7.95/-	Rs. 54.21/-	Rs. 8.72/-
2. Segregation & sale of garbage	Rs. 53.11/-	Rs. 16.10/-	Rs. 18.49/-
3. Generation of employment	Rs. 507.94/-	Rs. 218.63/-	Rs. 164.28/-
TOTAL BENEFIT	**Rs. 569/-**	**Rs. 288.94/-**	**Rs. 191.49/-**

Table 33: Costs and Projected Benefits in three areas of the slum for the COPRICOL-WRR.

	Gamdevi Dongri	Patkar Compound	Bhavan's & Dhangarwadi
Capital Costs	**Costs: (per day)**		
1. Trolley/day	Rs. 13.66/-	Rs. 4.27/-	
2. Dustbins	Rs. 58.45/-	Rs. 78.9/-	Rs. 2.56/-
3. Drums	Rs. 2.41/-	Rs. 4.09/-	Rs. 65.65/-
4. Garden sprinkler, sieve, shovel, plastic	Rs. 0.60/-	Rs. 131.51/-	Rs. 11.40/-
5. Consultancy	Rs. 57.70/-	Rs. 60/-	Rs. 98.63/-
6. Cost of pit	Rs. 4.38/-	Rs. 16.19/-	Rs. 60/-
Recurrent Costs			
7. Payment to the garbage collectors	Rs. 236.71/-	Rs. 4.68/-	Rs. 1.68/-
8. Salary of supervisors	Rs. 263.01/-	-	Rs. 3.18/-
9. Travelling	Rs. 60/-	Rs. 8.22/-	Rs. 0.18/-
10. Trolley repair	Rs. 3.54/-	Rs. 13.15/-	Rs. 8.22/-
11. Labour cost for composting	Rs. 8.22/-	Rs. 6.58/-	Rs. 0.70/-
12. Excel culture	Rs. 3.15/-	Rs. 57.70/-	Rs. 7.60/-
13. Excel solution	Rs. 6.66/-	Rs. 0.22/-	Rs. 57.70/-
TOTAL COST	**Rs. 718.49/-**	**Rs. 385.51/-**	**Rs. 317.50/-**

Projection: Benefits (per day)

	Gamdevi Dongri	Patkar Compound	Bhavan's & Dhangarwadi
1. Reduction in morbidity	Rs. 7.95/-	Rs. 54.21/-	Rs. 8.72/-
2. Segregation & sale of garbage	Rs. 53.11/-	Rs. 16.10/-	Rs. 18.49/-
3. Generation of employment	Rs. 507.94/-	Rs. 218.63/-	Rs. 164.28/-
4. Sale of compost	Rs. 75.00/-	Rs. 75.00/-	Rs. 75.00/-
TOTAL BENEFIT	**Rs. 644/-**	**Rs. 363.94/-**	**Rs. 266.49/-**

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Appendix - I

SURVEY OF GILBERT – HILL AREA TO ANALYSE SOLID WASTE PROBLEMS

I] FAMILY INFORMATION

Name of area/mohalla:-
Name:-
Address:-

II] FAMILY BACKGROUND INFORMATION:-

Name	Age	Relation	Sex	Marital Status	Education	Income	Occupation

III] RELIGION

Hindu ☐ Muslim ☐ Christian ☐ Other ☐

IV] Since how many years you are staying in Mumbai? ☐

V] Native language ______________________________

VI] Vegetarian ☐ Non-vegetarian ☐

VII] Who is the decision maker regarding sanitation and garbage disposal in your family?

DAILY HABITS:

1. Do you collect the garbage in the house before disposing?

Yes [ ] No [ ]

A. Where do you keep your garbage?

Plastic bag	Plastic box	Tin Container	Various things	Nothing	Other

2. Do you separate the waste before disposing?

Yes [ ] No [ ]

If Yes, how do you separate it?

If No, why not?

No time	No place	Someone else does it	Do not know	Never thought

3. How do you dispose the waste?

Throw it out	Burn it	Keep it in the bin	Nothing	Other

4. Who is responsible for collecting and disposing off the waste in your area?

BMC	On payment	Residents	Do not know	Other

5. Daily habits regarding waste disposal :

Time of waste disposal	Place for waste disposal	Quantity of waste thrown

6. Do you make use of the waste disposal facility provided by BMC?

A. If Yes, why?

Easy to use	Do not want in the house	Do not know	Other

B. If No, why?

Not easy to dispose off	Not available	One has to pay	Do not know	Other

7. What are the waste disposal habits of the other members of your family?

8. Waste disposal habits of children?

9. Do you pay for any waste disposal scheme?

Yes ☐ No ☐

A. If Yes, how much do you pay?

10. Are you satisfied with this scheme?

Yes ☐ No ☐

11. Would you like to have any scheme for garbage disposal?

Yes ☐ No ☐

A. How would you contribute to this scheme?

Pay money	In some other form

B. What will be your contribution?

12. What are the wastes disposed everyday from your house?

13. Is there anyone in your family doing waste picking?

Yes ☐ No ☐

A. Why do you pick up the waste?

Income	Food	Loans	Clothing	Other

14. What are the effects of waste picking over other jobs?

Less income	Less expenses	Nothing	Other

15. What types of vehicles are used to pick up the solid waste?

BMC truck	Private truck	Compactor	Handcart	Not known	Other

16. Where does the majority of waste is dumped?

Inside the slum	Outside the slum	Anywhere	BMC box	Not known	Other

17. Does BMC takes responsibility to collect the waste?

Yes ☐ No ☐ Not known ☐

A. If Yes, are you satisfied with their work?

Yes ☐ No ☐

If Yes, why?

If No, why?

18. Is any dustbin available by BMC in your area?

Yes ☐ No ☐

19. What do you think about the surrounding of the dust-bin?

Need to improve	All right	Do not know	Other

20. If there is need to improve how would you like to suggest?

21. Are you satisfied with the people using the dustbin in your area?

Yes ☐ No ☐

If No, why?

22. What do you think about the environment in your area?

Need to improve	All right	Do not know	Other

A. If there is need to improve what can be done?

23. Is there any informal sector labour involved in solid waste disposal?

Yes ☐ No ☐

If Yes, who are they?

24. What do you suggest to improve the overall solid waste management system?

25. what are the difficulties in collection of solid waste?

Irregularity	Less workers	Habits of the residents	Nothing	Other

HEALTH:-

1. Does solid waste have any effect on your health?

TB	Bronchitis	Asthama	Lung problems	Diarrhea	Worm infection

Malnutrition	Headache	Malaria	Fatigue	Fever	Other

2. Do you have any domesticated animals in your house?

Yes [ ] No [ ]

A. Which are they?

Dog	Cat	Goat	Chicken	Cow/buffalo	Other

B. Why do you have them?

Income	Food	Pets	Do not know	Other

C. Where do you keep the animals?

Inside the house	Outside the house	Courtyards	Other

D. What do you feed the animal?

Left over food	Anything	Vegetarian	Non-vegetarian	Other

E. What do you do with any waste generated from them?

Nothing	Gather it with other waste	Re use it	Do not know	Other

SANITATION:

1. Do you have a toilet facility inside your house?

Yes [ ] No [ ]

A. If Yes, where does the waste despised off?

No where	Do not know	Communal waste disposal unit	Paying for waste to be removed	Other

B. If you do not have a toilet, would you like to have one?

Yes ☐ No ☐

C. Do you have a space inside the house for a toilet?

Yes ☐ No ☐

D. How much would you be willing to contribute for a toilet? How?

2. Do you use the public toilet?

Yes ☐ No ☐

A. If No, why?

Very far	Very dirty	Long queue	Not in working condition	Other

B. What happens with the waste of the toilet?

Nothing	Gutter	Drainage	Do not know	Other

3. How does environment get polluted in your area?

Water	Air	Soil	Do not Know	Nothing	Other

4. Do you get sunlight in your house?

Yes ☐ No ☐

5. Have you planted any plants?

Yes ☐ No ☐

If Yes, which type?

Ever green	Vegetables	Flowering	Creepers	Other

Why?

Decorative to room	As plants	To get food	Other

6. Are you interested in planting plants?

Yes [ ] No [ ]

7. What are the benefits of plants in the environment?

8. A. Which of the following benefits of plants is the most important to you?

B. Which is the least important to you?
   a. Adds beauty
   b. Produces food
   c. Cleans air
   d. Produces privacy
   e. Attracts birds
   f. Cools the air
   g. Reduces noise levels

9. What would you do to improve your environment in your house?

More space	More sunlight	More plantation	Nothing	Other

10. What would you do to improve your environment in your area?

Keep clean	Broaden the road	Greenery	Nothing	Other

11. How will you make use of vacant land of your area?
   a. Flower garden
   b. Open field of grass
   c. Community composting area
   d. Fruit and vegetable garden
   e. Children play area
   f. Nothing, leave it as it is

12. How would you like to implement this idea?

13. Do you separate out things like plastic, glass, tin, paper etc.?

Yes [ ] No [ ]

If Yes, what do you do?

If No, why?

14. In monsoon what difficulties do you face due to solid waste?

15. If BMC workers didn't collect the solid waste what is done with the waste?

16. Where do your children go for toilet?

17. How do you think it is possible to green your area with limited space?

Appendix – II

Date:

1. Area:
2. Name:
3. Number of family Members:

   Adults Children (< 12 years of age)
4. What do you store garbage/solid waste in the home?

   Plastic bag Plastic bucket/container Metal container Various things

   Do not store Other
5. Do you separate dry and wet garbage?

   Yes No

   If Yes, what are the things/materials you separate
6. What do you do with the separated dry/inorganic garbage.
7. What do you do with the separated wet/organic garbage.
8. Do you separate the dry and wet garbage daily?

   Yes No
9. If No, how often is the separation done?

   Once in 2-3 days Once a week Irregular
10. If no, why is the garbage not separated?
11. Who takes the responsibility for collecting garbage in your area/mohalla?
12. Do you pay for this service?
13. If Yes – What is the amount paid.
14. If No, please give reasons.
15. What is your opinion about the collector's work/performance

    Satisfactory Unsatisfactory
16. If unsatisfactory, please explain and give reasons.
17. Do you use the communal solid waste collection facility

    Yes No
18. Can you tell us something about environmental sanitation activities in your area?
19. What is the importance of environmental sanitation?
20. How do you keep your environment clean?
21. Would you say that your own area and the whole slum is clean?

    Yes No

22. Please give reasons for your answer?
23. Do you have problems/constraints is keeping the area clean?
24. If Yes, please state/specify?
25. How can you overcome these constraints?
26. Is the garbage collection regular?
27. Would you be willing with others to take the responsibility for environment sanitation?

    Yes No
28. If Yes, how?
29. If No, please give reasons?
30. Have you participated in any activity to improve the environment sanitation in your area?

- Pay the monthly contribution for garbage collectors. Salary but take no responsibility?
- Participate in signature campaigns?
- Attend meetings?
- When necessary, go personally to officials/local ward officers?
- Monitor and supervise the COPRICOL?

31. What are your requirements in order to keep your area clean?
32. To what extent environment cleanliness in order to keep your area clean?
33. To what extent environment cleanliness is it the responsibility of the residents? What are the specific responsibilities?

Appendix – III

Morbidity Data

Person to be interviewed is the mother or the head of household

Schedule No. ____________ Date: ____________

Area: ________________________________ RCV: ______________________

Address: ____

____

1. In the past 1 week, has any child below 5 years of age been ill? Yes / No

If Yes,

Name	Age	M/F	Type of illness	No. of days
			Diarrhea Cough & Cold Vomiting Fever Any other	

2. Does any member of the family, have any of the following health problems?

Health Problem	Name of the family member	Age	Sex	Since when has this person had this health problem
Tuberculosis				
Malaria				
Hepatitis				
Worm infestation				
Chronic cold & cough				
Asthma				
Typhoid				
Chronic skin diseases				
Any other				

Appendix IV

Training Inputs given to Collectors for Aerobic Composting

The Composting Process

The following steps are to be used. Based on this, a small handout was prepared in the local language and given to the RCVs and the collectors who do the composting.

1. Segregation of Solid Waste

The waste is to be separated into organic / biodegradable material which includes all cooked food waste, plant material, leaves, stems, stalks etc which have been discarded, coconut fibre, hay, sawdust etc. Polythene bags and paper, glass and metal if any, are separated and kept aside in a heap for pick up by the rag picker who visits the community bin daily. (Note: separation is done at the community bin). Each day at the 2 community waste disposal bins at least 1 to 2 bags (50kg capacity) of recyclable material are separated and collected by the rag pickers. Care is taken to ensure that no glass or metal bits are included in the biodegradable material that will be used for composting. The separation activity starts after the door-to-door collection of solid waste is completed.

2. Placing the Solid Waste:

Drums of 100 litre or 200 litre capacity are lined up. If necessary, leveling of the ground or pouring concrete may be necessary. Perforations are made in each drum, each perforation should not be more than 1 inch in diameter. The perforations should be approximately a foot apart, with about 12-15 perforations in each drum. It is necessary to have these perforations so that the material is sufficiently aerated. In a 100-litre drum, about 70-80 kg of fresh biodegradable waste is used. As soon as fresh waste is piled on, it is sprayed with the Excel solution. This is made by mixing approx. 1 tsp. (5ml) of the Excel OTC solution and 20 gm (4 tsps) of the culture (brown powder) in 3 litres of water. Both the solution and the culture (CELRICH) are procured from Excel Industries. This mixture is to be sprayed on the fresh waste on the first day only.

In 20 days, approximately 40-45 days, biodegradable garbage can be accommodated. After 6 weeks, the first drum would be ready. It can be emptied and the process started again. At all stages during the 40-45 days cycle, attention should be paid to the height of the material. It should be at least 1 metre in height. Care should be taken to pile the garbage loosely to allow sufficient aeration. Piles that are too low lose heat rapidly and therefore optimum temperature for destruction of pathogenic organisms and decomposition by thermophiles is not achieved.

3. Moisture Content

Attention must be paid to the moisture content. At the slum level, estimation of moisture is not possible. Hence the person who does the composting needs to assess the moisture qualitatively. If the composting mass appears too wet, especially if water begins to seep out of the perforations, sawdust and a little paper should be mixed in. If the mass appears too dry, water needs to be sprinkled. Garden water sprinkling should be used for the purpose. Special attention must be given to moisture content during monsoons and the hot summer months. In the monsoons, it is advisable to cover the drums with plastic sheeting to avoid the mass from becoming too soggy.

4. Changes occurring during the composting process

Within the first 2-3 days, the volume of the material decreases by about 40-50%. After a few days, there is a further decrease in volume such that the material may be only 30 to 35% of the original volume. At this stage, it is important to pay attention to the height of the mass. If the height is below 1 meter, material from drums filled and treated on consecutive days can be combined. The material must be turned every week and at the time of turning the temperature must be checked. As the decomposition proceeds, the colour gradually changes and darkens. By 3-4 weeks, the colour will have changed to a deep brownish or greyish – black material. The appearance of the compost and the odour will be similar to humus. The material will not be too hot to touch as it was before and there will be no off odour.

5. Aeration

Aeration is necessary not only for the thermophilic bacteria but also to reduce a high moisture content in composting materials. In the present project, turning of the material was done using rakes with long handles. Turning is done by hand, individually for each drum. If the mass appeared to be too moist/wet, turning is done more frequently i.e. once in every 3-4 days, instead of once a week. If there is little aeration, the material will undergo anaerobic decomposition. This is accompanied by possibilities of flies breeding, off odours and the risk that pathogenic organisms will not be destroyed.

Aeration during the whole process, but especially during the initial stages is important, because it intensifies the activity of the organisms and reduces the amount of time and space required for composting.

For aeration, the collector was asked to note the presence of foul odour since this would be indicative of anaerobic decomposition. If there is foul odour, turning should be done once in1-2 days, until the odour disappears. This will also help to control flies. (**Note**: If the Excel Technology is used, the problem of flies and foul odour will not be encountered within approximately an hour of spraying the solution).

6. Importance of Temperature

Temperature of the compost is to be monitored. This can be done by either inserting a rod deep into the mass, holding it for a few minutes and withdrawing it. The rod should feel too hot to be held in the hand easily. Alternatively, when turning the material, steam should emerge from the pile as it is opened once in a week.

7. Duration of Composting

If the process has been carried out correctly, the compost would be ready after 40 – 45 days of starting the entire process.

8. Drying and Packaging

Once the compost is ready, the drum is emptied on to a thick plastic sheet, spread out on an even surface. The compost is then exposed to the sun until, the moisture has evaporated. The material should flow fairly well when poured from the hand and should not be too soggy. The compost is then pounded, sieved and packaged. The sieving can be done using metal sieves (In India, sieves with medium sized perforations are available for sieving cereals like wheat. These sieves are useful and do not cost much). The compost is then packaged in polythene bags and the remaining material reused with fresh biodegradable material for composting.

Appendix V

Physical Analysis by Quartering Method

Procedure:

The sample from each trolley was mixed thoroughly and divided into four equal parts. Out of these four parts, two diagonal parts were taken and the remaining two discarded. The two parts were mixed and again divided into four equal parts. The two diagonal parts, which were on the other diagonal were taken and the other two parts discarded. This process was repeated till the weight of 12.5 kg was obtained.

The sample was then sieved through a sieve size of 1 cm. The part that was below the sieve was taken as inert and the part that remained above taken and the analysis was carried out, wherein the various constituents like paper, plastic, glass, metal, hay and straw, rags, biodegradable, crockery etc. were found out after separating them. This was then expressed as percentage of the total weight.

After physical sorting, fractions like metal, plastics, rubber etc. are set aside and the rest of the sample was then subjected for moisture content determination after which it was ground to a size passing through 0.35 mm pore size Tyler no. 42 sieve. The finely ground sample after mixing thoroughly was subjected to detailed chemical analysis.

Chemical Analysis:

I. Determination of pH:-

Buffer solutions of pH 4, 7 & 9 were made. The electrode was then dipped into each solution and the pH meter was calibrated.

A suspension of 5 g of well ground sample in 50 ml of distilled water was made and kept for aeration for 2 hrs. the suspension was then stirred to about ½ hr and the pH was determined with the help of the pH meter.

II. Determination of Conductivity:

A solution of known conductivity was prepared by dissolving 0.7455 g of potassium chloride in 1 liter of distilled waster. The cell was immersed in this solution and the reading was adjusted o 1.413 ms/cm and the conductivity meter was standardized.

A suspension of 5 g of well ground sample in 50 ml of distilled waster was made and kept for aeration for 2 hrs. the suspension was then stirred for about ½ a hour and the conductivity was determined with the help of the conductivity meter.

III. Moisture:

A known weight (500 g) of the sample was taken in a tray and heated in an electric hot air oven overnight at 100°C. the sample was then cooled in a dessicator and weighed. Percentage loss in weight was reported as moisture.

$$(\%)\ \text{Moisture} = \frac{\text{Initial weight} - \text{Final weight}}{\text{Initial weight}} \times 100$$

IV. Organic matter or loss on ignition:

The firely ground sample of known weight (5g) was placed in a previously weighed silica crucible and heated slowly in an electric furnace to about 700°C for 2 hrs. the silica crucible was cooled in a dessicator and weighed. The percentage loss in weight as reported as organic matter.

$$\text{Organic Matter}\ (\%) = \frac{\text{Initial weight} - \text{Final weight}}{\text{Initial weight}} \times 100$$

$$\text{Organic Carbon}\ (\%) = \frac{\text{Organic Matter}}{1 : 724}$$

V. Estimation of Total Nitrogen:

1 g. of the sample was weighed and put into a 500 ml Kjeldhal flask. To it add 3.5 g. of salicylic acid, 40-45 ml of conc. H_2SO_4, 4-5 crystals of Sodium Thiosulphate. Heat gently till effervescence comes. Solution turns black due to this, which is a dehydrating agent, which absorbs H_2O so the sample gets charred. Add sodium sulphate (to increase boiling temp.). then add $CuSO_4$, which acts as a catalyst.

Digest till solution becomes colourless. Take digested solution, add 50-100 ml. of D/W, with concentrated stirring under tap H_2O so that NH_3 will not release into the atmosphere. Add 2-3 drops of phenolphthalein indicator. Add 40 % NaOH till colour changes to dark green. Add to it a glass piece and zinc metal piece to avoid bumping. Take 50 ml. boric acid into conical flask. Dip tube into conical flask, distill prepared N_2 solution in conical flask becomes green. Titrate it against 0.14 N H_2SO_4 till colour changes to violet.

0.1 N HCl (3.646 g per lit.)

$$\frac{3.646 \times 100}{32} \text{ g of 32.1 HCl}$$

gives 1 litre of 0.1 N solution.

Specific gravity of conc. HCl is about 1.16

Therefore, volume of HCl required $= \dfrac{3.646 \times 100}{32 \times 1.16}$

$= 9.82$ ml/lit. for 0.1 N solution.

Standardize against std. 0.1 N NaOH using phenolphthalein indicator (titrate to pH 8.1).

Sub.	Specific gravity	Normality	Percent W/W	Milli litres to be taken to make one litre of 1 N solution (approx.)
HCl	1.18 1.16	11.3	35 32	89 98.2
HNO_3	1.42	16.0	70	63
H_2SO_4	1.84	36.0	96	28
Phosphoric acid	1.69	41.1	85	23
Acetic acid	1.05	17.4	99.5	58
Ammonium hydroxide	0.9	14.3	27	71

Phosphorus and Potassium:

Weigh 5 g sample. Ignite in muffle furnace for 2 hrs. at 610° C. Weigh to find out LOI. Moist with D/W (little). Add conc. HCl till effervescence stops. Transfer to beaker, wash all practicles clearly. Boil till it reduces to half the quantity. Then filter through 1 or 2 Whatman filter paper in 250 ml vol. flask. Dilute upto mark with D/W. take out 50 ml. solution for P & K each, in a beaker. For P reduce half the solution after boiling and for potassium dry completely.

Phosphorus:

Add NH3 till precipitate formation. Add conc. HNO_3 to dissolve precipitate. Take 11 ml conc. HNO_3 in measuring cylinder, transfer it to beaker. Then measure 9 ml ammonium molybdate. Add this to P solution – yellow precipitate is formed. Allow settling overnight. Start filtering next day through Whatman filter paper no. 42. Wash the precipitate by regular checking for pH to be 6.

Dissolve the precipitate with 0.2 NaOH. Add solution till colour changes from yellow to white. Add 1-2 drops of phenolphthalein indicator. Titrate against 0.2 N HNO_3 till end point becomes colourless.

Potassium:

Wash, dried precipitate with the help of glass rod till it dissolves into D/W. Transfer through a funnel using Whatman filter paper no. 1 or 2 in 100 ml. flask. Dilute to mark. Take readings using flame photometer.

Reagents:

(i) 20 % Ammonium Molybdate solution:

200 g of Ammonium Molybdate was dissolved in 1 litre of distilled water.

(ii) 0.2 N NaOH Solution:

Dissolved 8 g of sodium hydroxide pellets in 1000 ml of distilled water.

(iii) 0.2 N Nitric Acid:

Mixed 12.6 ml of concentrated nitric acid in 10 ml of distilled water cooled it and made the volume upto 1 litre.

(iv) 4 % Boric Acid:

20 g of Boric Acid was dissolved in 1000 ml of hot water.

(v) 0.1 N Sulphuric Acid:

Mixed 3 ml of concentrated sulphuric acid in 10 ml of distilled water. Cooled it and made the volume upto 1 litre.

(vi) Mixed indicator:

Mixed 10 ml of 0.1 % bromocresol green in 95 % ethyl alcohol with 2 ml of 0.1 % methyl red in 95 % ethyl alcohol. The colour produced by this indicator in Boric Acid was bluish purple.

(vii) Sodium hydrogen solution (40%):

400 g of sodium hydroxide pellets was dissolved in distilled water and made the volume upto one litre.

Appendix VI

Morbidity Reduction Per Person (%)

Area	Diarrohea	Cough & Cold	Vomiting	Fever	T.B.	Malaria	Hepatitis	Worm	Asthma	Typhoid	Skin Disease	Any Other
Patkar Compound	2.3	16.40	1.50	7.22	2.50	4.50	- 0.35	2.30	2.50	0.804	1.80	10.80
Bhavans	- 2.67	1.04	- 0.73	- 5.24	0.28	0.28	0.28	2.78	2.78	0.28	1.02	-3.40
Wireless Road	- 0.54	2.57	- 1.11	- 1.29	-	- 1.0	-	10.48	1.18	0.78	1.57	0.84
Gamdevi Dongri	0.26	- 0.97	- 0.35	- 2.59	0.52	0.54	- 0.07	- 0.74	1.27	- 0.18	2.14	- 8.03